run must be estimated so that management might select the most profitable alternative.

METHODS OF FORECASTING

In an actual forecast, a number of techniques may be used. The identification of specific methods does not mean they should or must be used alone. In fact, as will be evident, it is sometimes difficult to separate one method from another, and there are numerous conceivable classifications. The techniques of forecasting to be discussed here in this paper will be classified under three basic headings—judgemental, projection, and model building and simulation.

Judgemental Methods

Emphasis is on the qualitative aspects of forecasting in this method, while a greater emphasis is placed on the quantitative aspects with the projection and model building and simulation methods. Within the projection methods, the techniques of trend analysis, correlation regression, time series, and surveys are presented. Model building and simulation are among the more exotic of the quantitative methods. This is broken down into models based on learned behaviour and simulation of the business through systems.

Techniques classified under judgemental methods are as follows :

Continuation of Current Conditions

This approach is sometimes called a "naive forecast" or a persistence prediction. It simply projects the current situation into the future. This method indicates that the future will be as it is now; and in fact, this method results in no change forecast at all. Production, sales, income or whatever is forecast, is predicted to remain at the levels shown by the latest available data.

This method does not have much support either in logic or historical fact, although widely used. The future grows out of the past and present but absolute stability is rare. Also, the degree of change is

in analysing historical data in order to calculate more accurately the remaining elements.

There are many possible models which may be used to represent the time series being analysed. The relationships may be linear or non-linear.

This type of analysis represents a greater mixture of quantitative and judgemental procedures. Judgement is required in developing criteria to decompose the time series, which is the objective of the analysis.

Time series analysis is not without its limitations. In time series analysis, it is assumed that time is causally related to the forecast variable. Another limitation is the complexity involved in attempting to determine shape of the functional relationships between the variables. Following this is quantitative procedures. Time series is perhaps more loaded with subjective judgement than other methods. For example, the desired seasonal indices are naturally dependent on the time period defined as a season. In fact, once judgement enters the analysis, results become subject to bias.

Finally, there is a tendency to regard time series analysis as an 'either/or' procedure. It is possible for an analyst to use time series or another tool, *e.g.*, regression analysis, combined.

Surveys

Survey consists of efforts to elicit information from others, e.g., consumers, distributors, or economists. Surveys can also be used for sales forecasting purposes. The forecaster, for example, surveys the buying plans of purchasing agents or the probable reaction of ultimate consumers to a new product.

In fact, the forecaster uses surveys for forecasting purposes in cases where historical data are judged not to be indicative of the future or are non-existing—*e.g., introduction of a new product.*

In using surveys as a forecasting tool, the first thing to be undertaken by the forecaster is to determine precisely the nature of the information needed. This is probably the most important phase of the survey, because

if it is poorly implemented all subsequent steps will be of no avail. The imformation needed can be obtained by using methods like personal interviews, mail, telephone, observation panels and group interviews, and test markets.

Surveys, like all forecasting methods, are not without shortcomings. One is possible leak of predictive power. This is not an inherent weakness, but one that results from inadequate data collection procedures. Another weakness of the method is high cost. Expenses are incurred in determining the survey plan, training, compensating the interviewers, etc. These expenses may be substantial, especially where the sample is large. Surveys can also be very time-consuming.

Test Market

This is another technique closely allied to survey methods. Here the forecaster arranges for the placement of a new product or brand, or modification of an existing one, in cities believed to be representative of the firm's geographical target market. The forecaster observes the sales behaviour in the test market over a period of time and often compares it to sales in control markets, those in which a different product or brand is being offered. The test market may be one in which particular merchandising, pricing, promotion or distribution tactics are being employed and control markets where they are not. The basic objective is to observe sales in a small-scale setting and the basic assumption is that behaviour in this setting will predict that of the market at large.

Model Building

Under the third classification, model building, econometric models will be discussed.

Econometric Models

In recent years a conspicuous part of the literature in economics has been devoted to the development of a new and powerful tool for analysing and forecasting economic activity—the econometric model.

This kind of model attempts to describe and predict economic activity in terms of a system of mathematical equations. In general, the econometric

approach to business and economic problems proceeds along the following steps.

First, observed economic relationships are formulated in terms of a set of testable hypotheses. Second, the hypotheses are translated into precise mathematical equations. Third, the parameters of the questions are estimated from past data and assumed values of current variables. Fourth, the values of the dependent variables of the model are forecast. Fifth, the relative importance of each of the explanatory variables is assessed and finally the entire model is evaluated in terms of its effectiveness to explain and forecast economic activity.

The primary purpose of econometric models, whether large or small, complicated or simple, is to determine the values of the endogenous variables, from the values of the predetermined variables. When the number of equations is equal to the number of endogenous variables, the model leads to unique answers, in which case the model is termed complete. Not all the equations of our model fulfill the just-mentioned purpose of econometric models. The consumption function, for example, does not express the endogenous consumption directly as a function of exogenous investment and government expenditures but as a function of national income which is equally endogenous.

There is now a variety of estimating methods available for use in determining the values of the parameters of an econometric model. Some of the more popular methods available are ordinary least squares, indirect least aquares, limited information maximum likelihood, full information maximum likelihood, and two-stage least squares. A complete interpretation and analysis of these methods is beyond the scope of this paper.

Econometric models are a powerful tool for assembling and evaluating economic data in a meaningful way. It can be used to give quantitative answers to a large variety of problems such as forecasting, testing of hypotheses, simulation of public policy programme, and so on. Perhaps, the most important use of econometric models is in the verification and refinement of economic theories. The models make it possible to empirically trace and reproduce presumed economic relationships. In short, it provides an invaluable link between theoretical formulation and empirical verification.

However, the limitations of econometric models are that they are cumbersome, expensive and new. But experience gained through econometric models can undoubtedly, lead to new and more refined hypotheses which will greatly enhance our understanding of the economic system and business fluctuations.

FORECASTING PROBLEMS

The first important fact of concern to the prospective forecaster is that no infallible way to predict the future has yet been developed.

Forecasting is not an exact science; although knowledge about economic activity has grown, no one can predict future economic activity with certainty. This, in fact, does not mean that the study be abandoned, but rather increased effort should be made to arrive at conclusions which utilise established data and methods.

Vital business decisions depend partially on estimates of the future, and, therefore, estimates should be carefully and thoroughly prepared.

The forecaster who seeks to first establish the causes of the fluctuations is faced with the fact that there are a number of possible explanations. The cause may change from time to time, and more than one cause may be at work; and the relative strength of each may vary.

The economy itself changes. New forces are introduced and old ones disappear and there appears to be almost constant change in the combination of forces that bring about business movements. All these forces affect the validity of explanations developed prior to the changes.

In addition, what happens in economic life is affected by forces which lie outside the economic system itself. Wars, for, example, have important effects on the economy; so do scientific developments and changes in the governmental and social structure.

The forecaster is also faced with a great volume of data, some of it is late, some is frequently and substantially revised and is of questionable validity. Therefore, to permit reasonably prompt conclusions, the data

must be organised. In spite of the data being organised and interpreted correctly, there may still remain a problem of combination.

If the forecaster decides to employ a causal approach, he is faced with a series of judgements and if he decides to employ non-causal approach, these series of problems may be reduced in number.

ASSESSMENT AND IMPLEMENTATION

A useful forecast method should encompass certain forms of validity. These are data validity, valid assumptions, causal validity, accuracy, flexibility, and reliability. A forecast, before it is implemented, should be assessed for its reasonableness. Various tests of reasonableness are possible, including comparison of the forecast with historical sales, consideration of factors which might alter the forecast level, employment of alternative methods as checks on the forecast, and examination of the validity of the methodology. An effective assessment process often requires a combination of two or more of those tests.

After assessment, the forecast is implemented. Here it is transmitted to the proper executives for transformation into budgets and planning tools. Implementation also requires convincing the executive that the forecast is likely to be accurate and that they should act upon it. The forecaster should be able to present the forecast in a manner that enhances its acceptance and to engage in follow-up activities that increase its chances of being acted upon.

FUTURE OF FORECASTING

Any discipline or managerial function can be expected to change over time and forecasting is no exception. Alterations in the methodology and uses of forecasting can be expected to increase; and these changes can be expected to take the form of more sophisticated forecasting techniques and their increased employment by management.

More Sophisticated Techniques : The passage of time should witness advances in the quality of forecasting technology. Among the forces

contributing to the elevation of the art are new developments in the social sciences, mathematics, research techniques and data processing.

Progress to date has been considerable as witnessed by analysts who use innovations in simulation, brand-share models and survey techniques. Increasing use of sensitivity analysis is only one indicator of advances in methodology. Virtually every phase of the forecasting process can be expected to become more sophisticated in upcoming years.

Increased Use of Forecasting by Management : It is likely that managements of future will use forecasting to a large extent than is the case now. Part of the impetus for this development will evolve from increasing educational levels of executives. Larger numbers of managers have college degrees, many of them in business administration. These better-educated managers are likely to give more importance to forecasting as a planning and control tool than did their predecessors. The modern manager is more likely to have the training required to understand the methodology and even to construct forecast models.

The increased pace of change is a second force that will contribute to increased employment of forecasting. More and more products are displaying shorter life cycles, industry sales change abruptly, producing rapid and significant fluctuations in company sales. These forces of change will make it necessary for managers to be in possession of methods which will signal what is expected to take place in the future.

In the future, cost pressures on management are expected to be a continuing reality. These will take the form of increments in wages, power rates, interest rates and cost of raw materials, supplies, parts, and equipment. These cost advances will put pressures on management to produce effective plans and controls.

Also, increases in the intensity of competition can be expected to generate increments in forecasting use. As competition, both foreign and domestic, steps up, managers will be forced to use effective forecasting processes to compete with rivals who are enhancing their own forecasting abilities.

Finally, the increasing sophistication of methods should help produce more usage of forecasting. As methodology improves and becomes more accurate and precise, managers can be expected to rely on forecasting more than they did in the past. Better tools are likely to yield wider use. □

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Heuristic Methods for Decision Making

R.J. Tikekar* & Sadananda Sahu**

INTRODUCTION

In an age of rapidly expanding technology and methodology, the language of science has inevitably crept into the vocabulary of the business world. One of them that is appearing with increasing frequency in the literature of interest, to the thoughtful businessman is "heuristics". It often appears in such terms as "heuristic search" or "heuristic programming".

Meaning and Significance

In early days, heuristics was the name of a branch of study belonging to logic or philosophy, the aim of which was to investigate the methods of discovery and invention. In present usage, the meaning has somewhat expanded. A heuristic is itself an aid to discovery, especially the discovery of a solution to a problem. It has been described as "a rule of thumb, strategy, trick, simplification or any other kind of device which drastically limits search for solutions in large problem spaces" [11].

Familiar Examples

We all use heuristics in our daily life, drawing from our knowledge and experience to enable us to solve the countless problems that confront us. Consider the simple rule "when the sky is cloudy, take an umbrella to work". We could have used more complicated problem-solving processes like studying the weather chart or ringing up the weather bureau. In many problems of this sort we lack the time or inclination to adopt more complicated problem-solving processes. A simple, though not infalliable, rule serves us best.

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Businessmen frequently develop and follow various heuristics in their own operations, perhaps without realising that they are using a type of heuristic problem-solving. The following examples will illustrate this point :

Inventory Control : When the stock goes down to four that is the time to place an order. Such heuristics are called trigger-level rules.

Accounting : Value at cost or market whichever is lower or first in first out.

Management : Handle only the exceptional problems ; let subordinates decide routine matters.

Structured and Ill-structured Problems

Structured problems are those which can be expressed in mathematical form. They have an objective function which may have to be maximised depending on whether we are dealing with profits or costs respectively. Most of the problems encountered on Operations Research fall in this category. Optimal solutions through mathematical computation is possible in many cases, but heuristics are employed to get a satisfactory solution with considerable reduction in computational effort. In some cases, because of the large combinatorial nature of the problem, mathematical solutions are not possible and in such cases only heuristic techniques have to be employed.

Ill-structured problems cannot be expressed in mathematical form. Judgement, intuition, creativity and experience are important elements of the problem-solving process. Heuristic techniques have been developed for solving such problems. Their object has been to develop computer programmes that imitate certain human problem-solving process. Among this category are programmes which prove mathematical theorems, play chess, write music, etc.

Heuristic Search for Solving Structured Problems

Heuristic search is based on examining the effects of small changes on the best point already known. Its success depends on the existence

of better points near any non-optimal point. A pictorial model of such a situation is a hill. From any point except the top of the hill, it is possible to take a small step that leads upward to a higher point. Repetition of this simple procedure ultimately leads to the optimal point—the top of the hill. Hill climbing is thus analogous to a heuristic search procedure for seeking an optimum [10].

Heuristic Search for Solving Ill-structured Problems

Before the advent of computers the solution of ill-structured problems had been the exclusive preserve of human problem solvers. A number of heuristic programmes have since been constructed or designed. They cover a wide range of tasks—playing chess, checkers and bridge, solving geometrical theorems, etc.

Examination of these programmes reveal that only a few ideas seem to be involved, despite the diversity of tasks. These ideas, if properly expressed, can become a collection of methods. Examination of these methods shows them to be extraordinarily weak compared to the methods of linear programming. In compensation they have a generality that lets them to be applied to diversified tasks where strong methods are unknown.

DECISION MAKING PROCESS

In discussing how executives make decisions, let us distinguish between two types of decisions. These will be called programmed and non-programmed respectively. These are not distinct types of decisions but a whole continuum of decisions, programmed at one end and non-programmed at the other.

Decisions are programmed to the extent that they are repetitive and routine and a definite procedure has been worked out for handling them. The obvious reason why programmed decisions tend to be repetitive is that if a particular problem recurs often enough, a routine procedure will usually be worked out for solving it. Examples of these are pricing ordinary customers' orders ; determining salary payments to employees who are ill, ordering office supplies, etc.

Decisions are non-programmed to the extent that they are novel, unstructured and unusually consequential. There is no hard and fast rule for handling the problem because it has not arisen before, or because its structure is elusive or complex or because it is so important that it deserves special treatment. A good example of this is the decision of a company to establish operations in an area where it has not been before.

The main reason for distinguishing between programmed and non-programmed decisions is that different techniques are used for handling these two aspects of our decision making.

The traditional and modern decision-making techniques are shown below :

Types of Decision	*Decision-Making Technique*	
	Traditional	*Modern*
1. Programmed, Routine, Repetitive Decisions	1. Habit	1. Operational Research : Mathematical Analysis
	2. Clerical Routine	2. Electronic Data Processing
	3. Organisation Structure	
2. Non-programmed One-shot, Ill-Structured, Novel	1. Judgement, Intuition and Creativity	Heuristic Problem-Solving Techniques Applied to:
	2. Rules of Thumb	(a) Training human decision makers
	3. Selection and Training of Executives	(b) Constructing heuristic computer programmes

There are several ways in which decision making can be made more effective. One of these would be to discover how to substantially increase the problem-solving capabilities of human beings in non-programmed situations. Another way would be to discover how to use computers to aid human beings in problem-solving without first reducing the problems into mathematical or numerical form.

Understanding Human Problem-solving Processes

It is only in the past twenty years that we have begun to have a good scientific understanding of the information processes that human beings use in solving problems and making non-programmed decisions.

Consider, for example, a case wherein the problem of solving a theorem of geometry is assigned to a person and he is asked to think aloud while he solves it. This will give an idea about the course his thought takes. A tape recording is taken of what he says during the ten or fifteen minutes he works on the problem.

From the tape recording it can be observed that the subject compares the theorem to be proved with some theorem he knows or he looks for similarities and differences. These suggest sub-problems whose solution may contribute to the solution of the main problem. It has to be proved that two triangles are congruent. The question which the subject will ask himself, "Are any pairs of sides equal ? Are any pairs of angles equal ?" Sub-problems may, in turn, generate new sub-problems until he comes to a problem he can solve directly. Then he climbs back to the next level of problems. He gradually begins to assemble results that look as though they will contribute to the solution of the whole problem. He persists along a path as he gets warmer, backs off to another direction of search when he finds a particular trail getting cooler.

Heuristic techniques employ a similar process. The primary test has been to construct a synthetic thought process in the form of a computer programme, present a problem to the programme, and compare its protocol (i.e., the computer trace) with the thinking-aloud protocol of a human problem solver given the same problem.

Means-End Analysis

A number of important processes that have been observed to account for human problem-solving are captured in a simulation programme, called GPS (General Problem Solver). It is called GPS, not because it can solve any kind of problem but because the programme itself makes no specific reference to the subject matter of the problem. GPS is a

programme that can reason in terms of means and ends about any problem that is stated in a certain general form.

GPS solves the problem as follows : Its programmes enable it to formulate and attack three kinds of goals :

1. *Transform goals* : Change a into b.

2. *Reduce difference goals* : Eliminate or reduce the difference between a and b.

3. *Apply operator goals* : Apply the programme to the situation a.

Apart from their use in psychological theory, some of the ideas of GPS have had practical application in artificial intelligence. Many problems are encountered in Operations Research work that are simply too large to be handled by mathematical techniques (e.g., linear programming or integer programming) that are available for finding optimal solutions. Large combinatorial problems, like the problem of scheduling a job shop, are often found to be too big for methods of mathematical optimisation. In this case, the method known as heuristic search, based on ideas like those incorporated in GPS, provides a powerful means for finding good, if not optimal solutions.

EXAMPLES OF HEURISTIC PROGRAMMES FOR SOLVING SPECIFIC PROBLEMS

Job Shop Scheduling

If there are 'n' jobs and 'm' machines and if all the jobs are to be processed on all the machines, then the number of alternate schedules is $(n!)^m$. *e.g.,* If there are 5 jobs and 1 machine, the number of alternatives is 120, if there are 5 jobs and 3 machines the number of alternatives is 1.7 million.

The general approach of the analytical method is to consider the problem in its total system form of scheduling n jobs on m machines. The relative lack of success of this approach in providing a general optimisation method of wide applicability, has led to a switch in the

focus of attention from the total system to a simple decomposed sub-system view of the problem in which the job shop is considered to be a series of inter-related single machine scheduling problem. The success of analytical method directed at the single machine problem has encouraged the view that perhaps the optimal priority rules so determined might be applicable also, either directly or in a modified form, to the job shop scheduling problems [3].

The features of the heuristic techniques are :

(a) emphasis on small scale problems,

(b) simplified problem constraints, and

(c) simple objective function.

Warehouse location

The problem is to determine the geographical pattern of warehouse locations which will be most profitable to the company by equating the marginal cost of warehouse operation with the transportation costs, savings and incremental profits resulting from more rapid delivery [4].

The heuristic consists of two parts :

(i) Main part which locates the warehouses, one at a time, until no additional warehouse can be added to the distribution network without increasing the total costs.

(ii) The bump and shift routine which attempts to modify solutions arrived at in the main programme by evaluating the profit implications of dropping individual warehouses or shifting them from one location to another.

The three principal heuristics used in this method are :

1. Most geographic locations are not promising sites for a regional warehouse; locations with promise will be at or near concentrations of demand. This restricts the search to 1 percent of the locations.

2. Near-optimal solution can be developed by locating warehouses one at a time, adding at each stage of the analysis that warehouse which produces the greatest cost savings for the entire system. This will reduce the number of cost evaluations necessary.

3. Only a small sub-set of all possible warehouse locations need to be evaluated at each stage of the analysis to determine the next warehouse site to be added.

Similarly, heuristics have been developed for the location-allocation problem. In problems under this category, we are interested in determining the following :

(a) the number of sources,

(b) the location of each source,

(c) the capacity of each source.

Financial Accounting

The problem is to maximise the value of a firm's equity to its present stock holders. Simulation technique is used to generate the relevant financial information and heuristic technique is used to evaluate it.

Simulation refers to the systematic projection of results under alternative assumptions. Simulation is used to project expected dividends and market prices, varying sets of assumptions and alternative financial strategies. The heuristic approach refers to the decision making process where the best of a restricted set of reasonable strategies is adopted where "reasonableness" is determined by judgement.

Simulation and the heuristic approach are often combined if the alternatives involve multiple decisions over time. For example, the expected results of a selected set of reasonable alternable strategies may be projected or simulated over time. The financial manager would then select the strategy for which the simulated results best meet the objective, of course, in conjunction with an optimisation technique such as linear programming or differential calculus. For instance, we may

heuristically define the set of feasible strategies and then select one of them by linear programming.

In practice, finance managers have employed some variation of the simulation-heuristic approach for years [12]. For example, any long-range cash forecast which assumes a particular financial strategy belongs to this category. Thus, the financial decision-maker's experience should enable him to select a group of financial strategies which are not "obviously poor". Still, even this group will contain a large number of alternatives. Imagine the time necessary for preparing 500 or more forecasts under different assumptions. Fortunately, computers reduce the work required and simulation processes can be progressed with relative ease.

Large Project Scheduling

Planning techniques like PERT and CPM have been widely used by large project managers in recent years, but in their conventional form, they fail to consider the constraints imposed on activity scheduling when resources are limited. The usual problem facing project managers is allocating scarce resources among various competing activities in a way so as to keep the project on schedule and to minimise cost of resources used.

Heuristic programmes can be used to generate project schedules under varying conditions, simulating for the manager the anticipated effect of proposed resources changes or other scheduling constraints [9].

A simplified verson of a heuristic programme for scheduling a large project is based essentially on three heuristics :

1. Allocate resources serially in time. That is, start on the first day and schedule all jobs possible, then do the same for the second day and so on.

2. When several jobs compete for the same resources, give preference to the job with the least slack.

3. Reschedule non-critical jobs if possible in order to free resources for scheduling critical jobs.

With the help of the above heuristics we can find completion data for a project if there is a constraint on the availability of resources on a particular day.

Assembly Line Balancing

The problem of assembly line balancing consists of assigning tasks to groups (called work stations) such that :

(i) each task is assigned to one and only one group;

(ii) the sum of the times of all the tasks assigned to any group does not exceed the cycle time;

(iii) the number of groups formed is a minimum.

The Ranked Positional Weight Technique [2], largest candidate rule, and the method of Model and Young [6] assuming constant or variable work element time all fall under the category of heuristic methods.

Many more heuristics have been developed. The most serious drawback with all these methods is that they make no provision for more than one operator at equivalent work stations which is a common feature of many lines.

Plant Layout

Computerised programme for solving plant layout problems have been classified into two types :

(a) Construction Type : One which constructs a layout by building up a solution from scratch and successfully adding blocks until all blocks are placed in the layout. CORELAP [5] is the first construction type of algorithm.

(b) Improvement Type : This requires an initial layout to start with and successfully improves upon it until no more improvement is possible. CRAFT [1] is the first improvement type of algorithm.

Prediction of Scores for Football Games

A heuristic programme has been developed for prediction of southwest conference football games before season play begins [8]. Offensive and defensive power ratings of teams are computed, based on player strengths, results from previous years and game location. Accuracy of pre-season prediction was approximately equal to that of game-by-game prediction of sports journalists.

Large-Scale Linear Programming Problem

Heuristic techniques have been used for solving large-scale linear programming problems. The size of the problem is reduced based on some heuristic assumptions. Once the solution is obtained, the assumptions are tested for validity. In case any assumption is violated, the problem is reformulated and solved. The original problem with approximately 5000 structural variables and 1000 constraints was reduced to a problem with only 35 variables and 20 constraints. A near-optimal solution was obtained after 4 runs of the reduced problem [7].

CONCLUSION

A relevant question which crops up at this stage is, 'How does a manager determine what is a good heuristic programme ?' In most cases results cannot be compared with an optimal solution because the latter is generally not available. The minimum-length schedule for a large project with limited resources is frequently incalculable. The relevant and, in most cases, the only comparison that can be made is with results from traditional management techniques. A manager should evaluate the output of a heuristic programme with the following four questions in mind :

(a) Does it provide better results than our present methods do ?

(b) Are there incremental savings in resources ?

(c) Are computational effort and expense reduced without sacrificing the quality of work ?

(d) Is the information produced more timely, and are decisions reached earlier than by present methods ?

A few existing programmes have been tried and have passed the above tests; some have not been tried at all and the results of some programmes have not come in as yet. It should be noted that in all cases heuristic programmes which have been applied to the problems of business decision-making are special-purpose programmes; they have been designed to solve a particular problem. None of them are general problem solvers in the sense that the procedures used adapt to the particular tasks given to them. In conclusion, it should be noted that heuristic techniques do not guarantee an optimal solution. However, the solution obtained cannot be easily improved upon. Heuristic techniques have been primarily designed to reduce computational effort. This advantage, more than adequately, offsets the disadvantage of a sub-optimal solution. □

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Development or Stagnation ? : Essence of Economic Development

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One single factor responsible for man's outstanding material progress is his urge for "good living". This urge has always been the motive force behind advancement of human knowledge to improve continuously the quality of life.

Man's aspiration for better conditions of living has led to search for new knowledge, leading to scientific discoveries and technological achievements, which are the essential factors for material progress through rapid increase in productivity.

Material prosperity of any nation is closely linked with its economic development. The mere availability of science and technology does not guarantee economic development. Only judicious use of science and technology to increase productivity through better management can create conditions for such development, which, of course, needs well-trained manpower.

Economic development can be quantified in terms of growth of agricultural production and industrial output. Such a development is mainly to optimise agricultural production by increasing productivity of land through application of science and technology and proper use of man and machine and to increase industrial output by expanding and diversifying industrial activities by using uptodate technology. Balanced economic development needs both modernisation of agriculture and rapid industrialisation, to grow like 'Siamese twins' - one cannot be sustained without the other. Slowing the process of growth of one will affect the growth of the other. The ultimate result will be economic stagnation.

To appreciate the position, one may need answers to questions like: how can one modernise and improve agricultural growth without industry producing fertilisers, pesticides for the farms, farm machinery and equipment, power generation and transmission, vehicles for transport of agricultural products etc; how can agriculture grow rapidly if industries

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which process agricultural output do not grow equally fast; how can agricultural production be increased with application of science and technology without the basic industries producing chemicals, metallurgical products, machine tools, etc. Therefore, development of heavy industries is as important as development of agriculture. To the extent that heavy industries are necessary for basic self-reliance and for producing machines and other outputs, for consumer goods industries and for agriculture, they must exist and grow for proper economic development of a country within the natural constraints like availability of trained manpower and other resources.

Narrowing the Gaps

Much has been talked about at international and national forums about the need for narrowing down the gap between the developed and developing countries in terms of existing economic disparities by establishing a better economic order, thus creating conditions for a world of peace and prosperity. This does not mean that poverty should be distributed equally to bridge the existing gap between 'haves' and 'have nots'. This, in fact, implies that the developing countries should be brought to a minimum level of economic development as rapidly as possible to narrow the gap, which, in turn, needs higher rate of growth in developing countries.

World experiences, have shown that higher rate of growth can be achieved only through rapid industrialisation and improvement of agriculture. There cannot be any other alternative to bridge the gap except that developed countries voluntarily reduce their consumption pattern now to the existing below standard level of prosperity they are enjoying, which is impossible even to conceive.

It is rather unfortunate that what is preached is not practised. So far, strategies for development suggested to developing countries, are not directed to developing self-generating economies. They are mostly motivated and influenced by other factors—like the self-interest of other countries or understanding of policy-making authorities blinded by some right traditional thinking for a short-term benefit. It is a pity that either some of the developing countries are in confused state to formulate right strategy of development due to lack of trained manpower or others

who have no dearth of competent people to formulate right type of strategy, are sold to their own ideas and fancies. If a country refuses to learn from others' experience and frames its own strategy without reference to such experiences, what can one do ? What can one do, if a man sits in a closed room surrounded by mirrors on all sides where one can see only his own image and admires his own personality ? The difference can be appreciated by him only if he cares to replace these mirrors with windows opening on all sides and see the world outside and others' achievements. Then alone his personality will grow and he can realise his shortcomings.

World's Experience

A careful study of the post-war (World War II) trends in Europe and other countries over a decade or so establishes a close relationship between economic growth and change in employment pattern and structure. With progressive enonomic growth, percentage share of employment increases rapidly in the industrial sector whereas it decreases sharply in the agricultural sector although there has been substantial increase in agrtcultural production through application of science and modern technology. In order to support the strategy of labour-intensive agriculture, the example of Japan is often quoted. During the last thirty years, employment opportunities in agricultural sector in Japan, have shrunk from over 50 percent of its labour force to less than 15 percent. Japan has become the only truely industrialised country in the East and one of the largest economies in the world. According to a survey conducted in 1946, 5.3 percent of the total labour force were unemployed and if those who worked only one to seven days per month were added, the portion rose to 12 percent. However, in 1960s, the labour surplus was changed into a labour-short economy in Japan (ILO Study). This could happen only because of timely realisation of the advantages of rapid industrialisation.

Analysis of economic development of the USA over the last fifty years, shows that with economic development, employment opportunities in the agricultural sector have shrunk to less than 25 percent of the labour force which was engaged in agriculture, although today American agricultural industry provides food not only for Americans but for millions elsewhere in the world. American agricultural productivity between 1930 to 1950 increased by 40 percent and between 1950 to 1975 by another 46 percent

(compound). What makes American agriculture so productive? The answer is simple. Success of American agriculture is the application of science and technology, supported by a massive manufacturing industry and by continuously adopting new techniques. In fact, many of the innovations of US farming have involved transfer of functions from the farm to factory. Today less than five percent of US workforce labour on the farm. However, 25 percent of the labour force is employed directly or indirectly in agro-business.

Today American agriculture is highly capitalised and the country earns over $21,000 million per year on export of agricultural products (American agriculture-focus, *Horizen,* No 17).

There are many other countries like Hungary and Denmark, which though predominently agricultural countries even after World War II, had to change the pattern in order to accommodate modernisation of agriculture supported by proper industrial growth. Cases of Korea, Malayasia, Phillipines and other countries could be cited where there have been sharp drop in employment opportunities in the agricultural sector and proportionate increase in employment in the industrial sector. Indian planners and decision-makers should study developments in these countries and take advantage of their experiences.

Indian Strategy

The experiences and trends the world over show that with the economic growth percentage share of employment in the agriculture sector sharply decreases. Even in a country like Afghanistan, this holds good. In fact, world experience establishes that like per capita consumption of energy or steel, rate of reduction in percentage share of employment in the agricultural sector is an indicator of economic growth. However, India, is perhaps the only country, where percentage share of employment in agriculture remained almost steady since 1921, rather, it increased in 1971. In 1921, 73 percent of labour force was engaged in agriculture and according to 1971 census, 73.8 percent of labour force was employed in agriculture in 1971. India is really a sole exception. What is the net result ? India's development is a sad story. Over the last two decades it presents a picture of contrast, lower growth rate in gross domestic product despite improved savings and investment

trends. A little advantage, the country got was through increase in agricultural production with the help of improved seeds, irrigation facilities, etc., but it will be difficult to sustain this advantage unless agricultural productivity is improved through intensive use of science and modern technology and by changing the employment pattern which will sharply reduce the percentage share of employment in agriculture. This measure has to be reinforced by rapid expansion of industrial activities. In India, land use is more than it can sustain. For ecological balancing in some of the states a portion of their land under agriculture may have to be reduced for giving preference to forestry development. Therefore, productivity in agriculture has to be improved much faster, to make the country not only self-sufficient but to be an exporter of agricultural products. On the other hand, if the present trend continues, it may be difficult to feed even its own ever-increasing population.

In spite of the position explained above and recognising the truth of the statement, no effective measures have been suggested in various plans. It has been admitted by the Indian planners that a drastic shift in the distribution of work force away from agriculture is normal and desirable; however, it is not likely to materialise in India in the near future. This would mean maintaining an inefficient agricultural system which will eventually bring the country to economic stagnation by perpetuating the low growth rate.

Obviously, India's strategy for development is based on short-term benefit. Its policy has created a vicious circle, all development activities leading to a self-stagnating economy, with sporadic efforts to revamp it. Its rate of growth is slow and still remains as one of the poorer nations in the world. India's economic development is a story of paradox. It has a broad base for industry and is perhaps one of the most advanced developing countries in terms of technical and industrial sophistication. It has one of the best assets, i.e., technical and scientific manpower with all sophistication. In fact, in terms of production of such manpower, India is rated as third in the world. It is a pity that such an asset has become a liability. Yet, in terms of broad economic indicators, India is still very much a rural agricultural country whose future is heavily dependent on vagaries of monsoon. Even the present strategy emphasises rural-based industrial development at the expense of capital building programmes.

Perhaps one of the reasons for creating the existing situation is the bogey of unemployment. It is very unfortunate that all human activities are quantified in terms of employment, after the World War II. Since unemployment has become a scare-crow for the economic planner in India, development plans are tuned to short-term benefits and credits, thereby sacrificing the long-term solutions to build a viable self-sustaining economic order in which much-needed capital can be formed quickly for financing labour-intensive activities like social services, maintenance services, etc. This short sighted policy is leading the country to an unretrievable position in future.

Human Resources—Unpredictable Entity

Much has been said recently about the emphasis on rural-based industrial development and Nehru's Industrial development policy has been criticised. Success of rural development will depend largely upon the will and participation of the people. One should not forget that manpower is a vital resource for any economic development. However, its development and utilisation have to be considered in terms a 'resource' and at the same time as 'human'. If it could have been viewed only from the resource angle, a planner's task would have been easy in the sense that like any other resource, human resource also could have been controlled and used like other resources.

However, it is the human aspect that adds a separate dimension to the problem. Human being is an autonomous entity. Man's behaviour is unpredictable as he decides his own action, motivated by his personal desires. The main objective of emphasising rural development projects is perhaps that of creating employment on a large scale. The question is whether this will be self-sustaining from the investment point of view. The question is whether, by doing so, one could check migration of labour from rural to urban areas which offer illusary promises for better employment opportunities and better quality of life in the actual sense of the term. Also whether, from investment point of view, it will be equally effective in terms of returns which could have been obtained from other capital-generating projects to recover economic position. Therefore, while planning on these lines, one should consider the acceptance of such a policy by the people at large, before it is launched.

One should not forget that ultimately major share of employment has to be borne by social and services sectors. However, in the first stage of economic development, attention should be given to those projects which are essential for rapid economic development and lays the foundation for a self-generating economic growth capable of offering better quality of life to majority of the population in quickest time.

Lessons to be Learnt

Many lessons could be learnt from India's experience on the one hand and world experience on the other, particularly by developing countries who are yet to develop their economy. It also teaches what happens when a country develops its own system of development strategy ignoring the experience gained already by others. Learning from others' experience is perhaps the most economic way of learning and one should not be hesitant to do so. Another lesson one can learn is that unless the economy reaches a critical stage, the country should devote itself in developing its economy in a way that it can achieve higher rate of growth through increasing productivity in basic sectors like agriculture and industry by application of uptodate technology, which can be sustained by its capabilities to train the right type of manpower. Sometimes starvation for a short time may be a better medicine for curing a disease which would have otherwise destroyed the individual. Temporary unemployment should not bother much. For the sake of solving temporary unemployment problem, that too for marginal benefit and for short time, a country should not reject a method of economic development which has been well tested and tried and, which may, in the long run, solve the unemployment problem most satisfactorily.

A developing country should also be prepared that, in its second stage of development, even the industrial sector is not able to generate proportionate employment in relation to economic growth. Whenever there is a paradigm shift in the industrial sector due to sharp change in technology during transition, there may be even zero growth in employment although there is a substantial increase in economic growth. That should not upset the authorities as it remains for a very short period and then it stabilises and comes back to normal. Any attempt to slow down the process of shift may harm the economy as it happened in UK in late 1950s. In this context, one may quote the

studies, which were undertaken by the ILO a few years back, in connection with the growth of employment in relation to economic growth in a few countries during 1963-69. The result of the study is presented below :

	Period : 1963–69 Growth expressed in percentage	
	Economic growth	*Employment growth*
USA	46	19
Canada	47	18
UK	26	0
West Germany	47	3
Japan	127	14
India	15	9

From the above table, it is clear that USA and Canada had already passed the transitional phase to switch over to modernisation of industry using uptodate technology and have stabilised their position, so there is a sign of substantial growth of employment with economic growth. As regards India, since no attempt had been made to change over by using uptodate technology, its growth has been slow, but the position was stabilised and there was a proportionate employment growth with economic growth, whereas in UK, West Germany, and Japan the position was different. These countries were obviously passing through transition from one system to another to achieve better growth through increase in productivity.

In the ultimate analysis, for rapid economic growth, a developing country should modernise its agriculture, supported by rapid industrialisation according to capabilities of its education and training system for training of appropriate manpower. At the initial stage, one should not worry about unemployment for a short period till the economy reaches a critical stage and becomes a self-generating system, and is capable of generating capital for the development of tertiary sector especially services and social services sectors which would generate large employment opportunities in the future. □

Work Stoppage in Indian Industries: The Reason

M. L. Monga*

A glance at the industrial-relations scene in India, during the past three decades, reveals that these have been swayed away by ever-increasing antagonism and strife. Industrial unrest has mounted unabashingly with a resultant loss in mandays and loss to the workers and the economy in terms of wages and productivity. During 1977, confrontation between labour and management took a dramatic turn, with as many as 2,230 cases of work-stoppages being registered. Though it appears to be a high jump from 1,459 cases in 1976 and 1,943 cases in 1975, yet, when compared to the pre-1935 days, it is only marginally higher. In 1974, there were 2,930 cases of work stoppage. On an average, 75 to 80 concerns were involved in industrial disputes per month in 1977.[1]

This paper is a modest attempt at finding an answer to the enigmatic phenomenon of work stoppages in Indian industries.

Magnitude of the Work Stoppage

If an accurate analysis of the functioning of industrial relations in the past two decades is attempted, it is seen that industrial unrest has turned perennial. The number of work stoppage cases went up from 1,357 in 1961 to 2,230 in 1977. The period 1970-74 appears to have experienced gross erosion of industrial peace as the number of disputes stood at 3,370 in 1973 closely preceded by 3,243 in 1972 and followed by 2,938 in 1974. The number of workers involved in work stoppage was the highest in 1974. The number of mandays lost reveals considerable waste of human resources, as the country was divested of 40 million mandays in 1974 alone, with a loss of 20 and 22 million mandays in 1973 and 1975 respectively. From 1961 onwards, there has been a continuous increase in case of work stoppage, workers involved, mandays lost, loss of wages and production value going up, etc. (Table 1).

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1. The Industrial Times, June 5-18, 1978, p. 10.

The value of wages and production dissipated as a consequence of work stoppage is appalling. The total loss of wages during the period 1973-77 works out to Rs. 1,000 million, accompanied by a loss of Rs 6,465.3 million of production value.

Table 1 : Number of Disputes, Workers Involved, Mandays Lost, Loss of Wages and Production Value During 1961-77

Year	*Number of disputes*	*Number of workers involved*	*Number of mandays lost (in thousands)*	*Value of wages lost (in Rs. million)*	*Value of production lost (in Rs. million*
1961	1,357	5,11,860	4,919	10.0	59.8
1962	1,491	7,05,059	6,121	—	—
1963	1,471	5,63,121	3,269	—	—
1964	2,151	10,02,955	7,725	—	—
1965	1,835	9,91,158	6,470	—	—
1966	2,556	14,10,056	13,846	60.7	326.9
1967	2,815	14,90,346	17,148	—	—
1968	2,776	16,69,294	17,244	—	—
1969	2,627	18,26,866	19,048	—	—
1970	2,889	18,27,752	20,563	—	—
1971	2,752	16,15,140	16,546	90.9	905.4
1972	3,243	17,36,737	20,544	139.1	1538.6
1973	3,370	25,45,502	20,626	—	—
1974	2,938	28,54,623	40,262	316.3	2096.1
1975	1,943	11,43,000	21,901	338.1	1778.6
1976	1,459	7,37,000	12,746	123.3	923.1
1977	2,230	15,75,000	16,415	84.2*	1123.7@

(—) signifies non-availability of the data.
* relates to 1,266 cases
@ relates to 1,177 cases
Source : Indian Labour Statistics, Labour Bureau, Simla.

The number of mandays thrown away divulges that these have acutely kept on surging and particularly the period 1966-77, has witnessed noticeable uptrend. The severity rate of industrial disputes in India suggests that it kept on swelling during the years 1961-75, excepting during 1971 and 1975, when it marginally declined. The trend projects dangerous implications if the present situation continues and hints that our ambivalence in this field may cost us grievously (Table 2). During the period 1971-77, about 1500 million mandays were lost. Undoubtly, a poor nation like India, fraught with unemployment cannot afford this enormous squandering of human resources,

Table 2 : Severity of Industrial Disputes in Manufacturing Sector

Year	*Mandays lost per 1,000 workers employed*	*Index (1961=100)*	*Severity* Rate*
1961	1,022	100	345
1966	2,041	200	808
1969	2,903	284	1,151
1970	3,353	323	1,631
1971	2,308	226	937
1972	3,036	297	1,226
1973	2,971	291	1,313
1974	4,483	439	1,973
1975	3,473	340	1,430

* Ratio of mandays lost to one lakh mandays scheduled for work.

Source : Pocket Book of Labour Statistics, 1972-78.

The break-up of the time lost by different sectors of economy per 1,000 workers employed shows that the manufacturing sector has maintained its leadership over the period 1961-75 closely followed by mining and plantations (Table 3). Plantations, coal, textiles (cotton, jute, silk and woollen) banking and insurance, docks and ports and railways, form the bulk of organised industry in the country. They have been responsible for 30 to 40 percent of the total work stoppage and 25 to 50 percent of the total time loss caused by all disputes in India.

Table 3 : Time Lost by Different Sectors of Economy per 1,000 Workers Employed During 1961-75

Year	*Mandays lost per 1,000 workers sector-wise*						
	Manufacturing	*Mining*	*Coal Mining*	*Plantations*	*Railways*	*Posts & Telegraphs*	*Transport & Communi-cations*
1961	1,022	532	489	174	—	—	—
1966	2,041	625	645	2,258	7	—	306
1970	3,329	1,375	1,191	317	16	—	902
1971	2,328	1,675	1,639	2,116	257	85	479
1972	3,231	2,293	2,502	623	27	10	202
1973	2,971	2,079	1,897	476	392	2	536
1974	4,505	1,029	1,465	3,380	6,329	14	—
1975	3,588	272	400	64	69	—	274

(—) indicates non-availability of data.

Source : Indian Labour Statistics, Labour Bureau, Simla.

Classification of Work Stoppage by Strikes and Lockouts

A probe into the statistics pertaining to strikes and lockouts reveals that strikes have prompted about 84 to 94 percent of the work stoppage in the country. The percentage of lockouts too has gone up from 6.38 in 1962 to 15.39 percent in 1975, with the period 1972-76 witnessing a significant addition to their occurrence (Table 4). The analysis unveils that strikes have emerged as a major basic tool employed by the industrial workers to ventilate their grievances and make their voice reach the managements. Lockouts, in fact, have sometimes been the consequence of an illegal strike or other extraneous reasons.

Table 4 : Percentage Classification of Work Stoppage by Strikes and Lockouts

Year	Percentage of Disputes		Total
	Strikes	Lockouts	
1961	91.37	8.63	100.0
1962	93.62	6.38	100.0
1963	92.72	7.28	100.0
1964	92.09	7.91	100.0
1965	92.47	7.53	100.0
1966	92.05	7.95	100.0
1967	86.42	13.58	100.0
1968	88.29	11.71	100.0
1969	89.22	11.78	100.0
1970	89.92	10.08	100.0
1971	90.04	9.96	100.0
1972	88.09	11.91	100.0
1973	87.74	12.26	100.0
1974	85.43	14.57	100.0
1975	84.61	15.39	100.0
1976	85.05	14.95	100.0

Source : Indian Labour Statistics, Labour Bureau, Simla.

Causes Behind Work Stoppage

A sifting of the causes behind the industrial unrest during the years 1961-76 (Table 5) reflects that wage-related matters (monetary issues) have predominantly maintained lead in promoting industrial dissension. Disputes resulting from personal and retrenchment issues have secured secondary status, followed by disputes relating to indiscipline and violence which gradually mounted from 3.2 percent in 1968 to 9.9 percent in 1976. The accretion of these disputes succeeded in injecting a touch of militancy in the field of employer-employee relations.

Table 5 : Percentage Distribution of Work Stoppage by Causes

Year	Causes						Total
	Wages and Allowances	*Bonus*	*Personal and retrench-ment*	*Leave and Hours of Work*	*Indiscip-line and Violence*	*Others*	
1961	30.4	6.9	29.3	3.0	—	30.4	1,314
1962	30.2	12.3	25.2	0.7	—	31.6	1,474
1963	27.8	10.0	25.9	4.6	—	31.7	1,466
1964	34.9	7.9	27.4	2.0	—	27.8	2,122
1965	33.5	9.9	27.3	2.5	—	26.8	1,825
1966	35.8	13.2	25.3	2.4	—	23.3	2,536
1967	39.9	10.9	23.6	1.0	—	24.6	2,760
1968	38.4	9.4	28.2	1.9	3.2	18.9	2,717
1969	36.0	10.0	26.6	2.2	3.8	21.4	2,609
1970	37.1	10.6	25.6	2.1	3.8	20.8	2,843
1971	34.3	14.1	23.0	1.4	3.6	23.6	2,723
1972	31.8	8.4	24.2	1.4	5.1	29.1	3,153
1973	34.1	10.3	24.3	1.5	5.7	24.1	3,296
1974	36.1	6.2	26.5	1.6	6.2	23.4	2,863
1975	32.0	7.9	29.9	2.3	8.9	19.0	1,912
1976	23.4	13.8	29.9	2.9	9.9	20.1	1,459

Source : Indian Labour Statistics, Labour Bureau, Simla.

The statistics emphatically pinpoint our failure to maintain a reasonable relationship between wages, incomes and prices, for, nearly 50 percent of the total disputes were induced by wage and bonus-related demands every year. This fact can be further substantiated by the data presented in Table 6 which shows that the index of money wages went up from 106 in 1962 to 205 in 1975 whereas the index of real wages declined from 103 in 1962 to 95 in 1973 with a marginal increase during 1968-72. On the other hand, consumer prices have maintained a galloping pace leaving the money wages and real wages far behind. The index of industrial production registered an increment from 109.2 in 1962 to 202.7 in 1974[2] but unfortunately, the worker could not receive any share

Table 6 : All India Consumer Price Index/Index of Money/Real Earnings in Manufacturing Industries

(1961=100)

Year	*Consumer price Index*	*Index of money earnings*	*Index of real earnings*
1961	100	100	100
1962	103	106	103
1963	106	109	103
1964	121	114	94
1965	132	128	97
1966	146	139	95
1967	166	151	91
1968	171	160	94
1969	169	170	101
1970	178	180	101
1971	183	185	101
1972	194	199	103
1973	236	216	95
1974	304	207	N.A.
1975	321	205	N.A.
1976	306	N.A.	N.A.
1977	313	N.A.	N.A.

N.A. indicates non-availability. *Source :* Pocket Book of Labour Statistics, various issues.

2. *Indian Labour Statistics*, 1976.

of this prosperity because of the exceptional rise in the consumer prices and absence of any reasonable system of compensation.

Work stoppage percolating from personal and retrenchment issues also liquidated incessantly the industrial harmony and thereby defeated the plethora of labour legislation in the country meant for bringing order in employer-employee relations. During the period 1961-76, 23 to 30 percent of the work stoppages were the procreation of these causes and their existence is a reflection on the slipshod implementation of the legislative provisions or their contravention. The statistics suggest that our legislative approaches for establishing industrial peace have proved more or less mere platitudes.

Classification of Work Stoppage by Results

Cases of work stoppage are classified by results from the workers' point of view, indicating the extent to which the demands of the workers are met. 'Successful' disputes are those in which demands of the workers are fully met. 'Unsuccessful' disputes are those where the demands are not accepted. 'Indefinite' disputes mean that no final decision is available at the time of resumption of work. 'Indefinite' disputes have ranged between 4.18 percent to 22.2 percent during the period under study. The percentage of successful and partially successful work stoppage has varied between 20 to 37 percent and 14.8 to 28.0 percent respectively over the period 1961-76. Unsucessful disputes have progressively increased form 29 percent in 1961 to 44.1 percent in 1976 (Table 7).

An unsuccessful work stoppage has a number of psychological repurcussions, as it generates a kind of tension among the workers and they try to build defence mechanisms against their injured feelings. They are then always on the look-out for an opportunity to take 'revenge' of their 'defeat' in the earlier encounter. This pscyhological warfare creates a vicious atmosphere. Another concomittant inference which emanates from the present analysis is that perhaps some of the strikes appear to have been organised on insignificant issues since a substantial number of strikes have only partially succeeded or completely failed to produce any results.

Table 7 : Percentage Distribution of Disputes by Results

Year	Results				Total
	Successful	Partially Successful	Unsucessful	Indefinite	
1961	28.8	19.5	29.5	22.2	1,139
1962	30.2	18.3	30.7	20.8	1,395
1963	23.4	17.9	41.0	17.7	1,398
1964	27.7	14.8	37.2	20.3	2,039
1965	30.7	13.5	35.9	19.9	1,760
1966	31.6	16.5	31.4	20.5	2,350
1967	33.3	15.8	34.7	16.2	2,566
1968	30.0	18.4	36.3	15.3	2,538
1969	35.2	17.1	31.2	16.5	2,415
1970	34.4	17.0	33.4	15.2	2,614
1971	26. 4	23.4	34.4	15.8	2,512
1972	29.8	23.9	31.9	4.18	2,830
1973	36.6	20.8	33.1	9.5	2,870
1974	31.5	21.1	38.5	8.9	2,433
1975	23.7	26.1	40.8	9.4	1,642
1976	20.5	27.1	44.1	8.3	1,459

Source : Indian Labour Statistics, Labour Bureau, Simla.

Analysis of Work Stoppage by Duration

Classification of work stoppage by duration relates only to those cases for which data are available. Percentage of the disputes which lasted only for a day or less has varied between 22 to 36 percent during 1961-76. Work stoppage continuing for more than one and up to 5 days have ranged between 23 to 26 percent. If the above two categories are combined, work stoppage of 5 days or less will account for about 50 to 60 percent of the total disputes. Disputes waged by any protest or over some minor issues or for drawing attention of the management or the state to some important grievances are not likely to

last long and these have dominated the industrial conflict in our country. The statistics also project the doleful functioning of the employer-employee relations at the plant level and confirms the existence of communication gap between the two. Disputes ranging between 12 to 17 percent had a duration of five to ten days and between 10.2 to 15.3 percent had a duration of more than 10 days but up to 20 days over the period under study. Work stoppage which have lasted for more than 20 days and upto 30 days have fluctuated between 4.3 percent to 24.0 percent (Table 8). In those cases where demands centred round major issues or where workers and managements demonstrated an uncompromising attitude, strikes and lockouts resulting therefrom tend to be prolonged,

Table 8 : Percentage Distribution of Disputes by Duration

Year	Duration					
	One day or less	*More than 1 upto 5 days*	*More than 5 upto 10 days*	*More than 10 upto 20 days*	*More than 20 upto 30 days*	*More than 30 days*
1961	31.2	32.2	12.5	10.2	6.0	7.9
1962	31.3	27.3	11.3	9.7	8.3	12.1
1963	36.1	35.6	13.6	6.2	3.8	4.7
1964	31.6	30.5	14.3	10.7	5.0	7.9
1965	31.2	30.8	13.3	9.6	5.6	9.5
1966	30.8	27.3	14.8	12.8	5.1	9.2
1967	26.2	29.0	13.8	12.2	6.5	12.3
1968	29.2	24.1	14.6	12.2	5.8	14.1
1969	27.8	28.3	12.4	14.2	6.7	10.6
1970	28.0	25.8	15.6	12.0	5.4	13.2
1971	25.4	25.1	14.8	15.3	5.8	13.6
1972	26.2	24.2	16.6	14.5	6.7	11.8
1973	24.7	25.1	12.2	13.4	7.9	16.7
1974	21.8	22.9	13.5	13.4	8.1	20.3
1975	22.6	23.0	13.8	11.0	6.2	23.4
1976	29.6	30.2	13.9	8.5	5.8	12.0

Source : Indian Labour Statistics, various issues.

The analysis reveals that a little careful handling of the situation by management as well as unionists could have avoided a significant number of cases of work stoppage. A more sagacious dialogue between the two could reduce the intensity of the ever growing work stoppage.

Conclusion

Industrial unrest is the progeny of conflicts between labour and managements. Conflicts are inevitable, for they are as old as work itself and are ingrained in the industrial system of a country.

Statistically, the data suggest that if we are able to maintain a reasonable relationship among prices, wages, real earnings and bonus, at least half of the industrial unrest would vanish. A wage price policy having a rational economic bias and sound inter-related mechanism must be chalked out to save the collosal loss of human resources, through work stoppage.

Increased acceptance and practice of theory 'Y' and participative management would also help reduce the conflicts. Enhanced opportunities for mutual deliberations, frequent flow of upward communication and timely action in case of grievances will build trust and confidence among the toilers and scourage their indulgence in work stoppage.

Managements and unionists, broach that their roles are complementary and supplementary to each other and that they must function coherently as a group. And yet, both of them very often seem to be more involved in strained relationships. This schizophrenic approach to handling employer-employee relations need to be thrown out of their minds and the existing communication gap between the two bridged if the much desired industrial peace is to be achieved. □

Cost-Effectiveness and Optimum Expenditure

P. Chattopadhyay*

Introduction

Cost-effectiveness considerations are significant determinants of whether a certain quantum of expenditure would be incurred or not by management for a purpose in view. The approach to application of the technique in India continues to be hesitant and half-hearted, if not utterly perfunctory. It is taken as too highly-sophisticated a technique to be useful to Indian conditions. That this is not so and that there is no reason to be scared require demonstration. Public discussion on the subject has also been rather few and far between. Its practicability can hardly be gainsaid due to its crystallisation from experience. It is by decision that management incurs expenditure by way of capital or revenue, depending on requirements. In such decisions, management, in most cases, is afforded at least two alternative courses of action, as to whether to incur the expenditure at all or otherwise. The magnitude, the costs involved and the results are naturally important parts of the decision to incur the expenditure in the first place.

Relevant Questions

There are several questions attending on the basic choice exercised by management which require evaluation. First of all, in most cases the primary expenditure becomes ineffective in conditions in which concomittant actions are not taken, maybe by way of incurring further expenditure or withdrawing from a course of action.[1] Secondly, the outcome being uncertain, at least for important strategic parts, managerial hesitation leads to incur as low an expenditure as possible, perhaps due to the proverbial fear of the whole effort going into a fathomless pit; like the wise men of old,whatever of the money going this way could be saved was a worthwhile effort. After all, the best way to save cost was not to

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1. The reports of the CAG and the CPU have brought several such instances to light.

incur it at all ! There occurs a snowballing effect of all these actions or inactions negating the very purpose for which expenditure is sought to be incurred. Instances are not far to seek. A highly paid man is appointed for organising research activities of an institution. He gets a stenographer only after about nine months of desparate attempts and on threat of resignation. His frantic attempts at getting such a minimum of essential secretarial assistance having failed, he could do no better than biding his time, doing practically nothing. Expenditure on the essential wherewithal should have, in fact, preceded his appointment, but that was not to be. In the mean time, however, the expectations of output ran high and the bosses accused him of inefficiency, on entirely wrong grounds. The expenditure initially made on his appointment and his salaries, etc., remained cost-ineffective. The position changed the moment a further modicum of expenditure was incurred in appointing his stenographer and output started pouring in. Wars are known to have been won or lost for petty things like pins or bolts and nuts. This proved a tragic truth in the present case as later achievements testified. Thirdly, the incurrence of expenditure, many a time, remains without defined objectives that are sought to be satisfied. Thus, whether the objectives behind the decisions are satisfied or not are not known and assessment of performance becomes a shady affair, to say the least. Fourthly, the objectives, where laid down, often remain so broad and ambiguous that management remains utterly confused as to what action is warranted. Last but not the least, the objectives sought to be satisfied are viewed so lopsidedly that the composite features thereof remain forgotton, often deliberately underplayed, making money go down the drain, rather than being put to planned use and fruitful pursuits.

Instances

The classic example is in several large-sized public sector projects in which only the technical part remains magnified, often at the cost of financial discipline and control.[2] It was estimated several years ago that with half the investment actually made we could have established the same industrial capacity as we had done at that time in India.[3] The

2. c.f. Sixtyfifth Report, CPU (4th L. S.) on MAMC, p. 93, indicating a loss of Rs. 18.9 million for non-investment of surplus funds in short-term deposits in banks.
3. c.f. Quarterly Reports of the Indian Institute of Public Opinion, New Delhi, 1963-64.

Committee on Public Undertakings observed that in several large public enterprises, key finance personnel were appointed only late in the day when some key decisions had already been taken and partly implemented. Any amount of subsequent jugglary could not avoid the excess load of expenditure in many of them, remaining as permanent drags, such expenditure having been capitalised as a part of the total project costs. The tragedy of the whole thing is that mistakes were often repeated and we turned a deaf ear to the lessons from experience. Cost of inefficiency became a permanent feature of most of our public sector capital projects.[4] The story of private sector enterprises cannot be drastically better, though in many respects they have a better picture to offer. However, taking into view that the public sector efforts have gone into areas where angels fear to tread, the intrinsic difference between them would require appreciation.

External Compulsions

Secondly, the compulsions in public sector enterprises have come from many external sources, mainly the government. As a consequence, most public sector projects had to implement plans formulated outside. They could not change the character of the plans even when glaring defects were seen partly because of lack of discretion given to project management and partly because sizeable expenditure and commitments were already made and there was little scope of going back on them. Reduced to the status of a 'pack of impotent men', the project managers watched the massacre of the concepts of economic viability and technical feasibility while tall claims continued tossing around.

Affected Economies

In the circumstances, the fundamental economies of their operations remained affected. Any amount of managerial sophistication at a later stage could not alter the picture totally. Such high magnitude of cost-ineffective expenditure in public sector has, in the past and also at

4. This occurred due to the capitalisation of the entire expenditure during the construction of a project as a part of the total capital cost of a project. Costs of delay and of operating inefficiency naturally are also capitalised.

present been related to choice of location of plants, choice of technology, choice of products or product-mixes, choice of personnel, choice of methods of production, choice of magnitude of investment, size of flow of funds, choice of markets, size of capacity to be installed, choice of head offices and distances between head office and plants in multi-plant set-ups, size of personnel and its composite features and a host of other factors that go into both capital and revenue expenditure. Managers are supposed to make the future today. These choices, therefore, largely determine how the units operate at a later date. The results of these choices remain ingrained in the projects all along the time and reflect on the operational economies of these enterprises.

Cost-Effectiveness

The foregoing details bring us to the heart of the matter namely, consideration of cost-effectiveness of expenditure as it is incurred and predicting cost-effectiveness for laying down cognitive criteria for helping management to take action calculative of risks and uncertainties and accommodative of centrifugal factors that tend to go out of track. Developing check lists is a part of the exercise and assesment of performance, according to the laid-down criteria, a regular and systematic affair, for taking corrective action as called for and changing the line of action, if necessary. Reference is made to facts related to both private and public sector enterprises without stating their identity unless these are from printed sources. Explanation of the technique of cost-effectiveness analysis is offered, elaborating those points that have a high significance for application in planning and controlling efforts and expenditure in the light of pay-offs in each case. It is but natural for management to seek to maximise the effectiveness of each unit of cost, in terms of pay-offs, subject to the constraints under which it operates, the objectives that it seeks to satisfy and the resources placed at its disposal. All this becomes more potent when it is considered that there are competing claims from various areas offering choices before management. To make the choice as good as feasible, cost-effectiveness criteria offer invaluable pointers towards making management sensitive to exercise rational choice within the bounds of feasibility. However, before dealing with the features of application, a few words about the technique should not be out of place here.

Features

Cost-effectiveness shows up in different situations. It may be the optimum point in certain cases, meaning least cost-high productivity conditions or least cost-high profit or high revenue-low price situation. It may be seen on a scale as the effect of one factor upon another or even as a joint effect of one or more than one factor upon another or a set of other factors leading to evaluation of incurrence of cost by way of input *vis-a-vis* efficiency of output of goods and services. For determining cost-effectiveness of sets of factors usually one or more may be shown on the vertical scale and the others on the horizontal. Movements plotted on the graph indicate a point of highest effectiveness of the combination. The movements are rather different in different cases requiring a close examination for knowing and judging the point at which the best results are shown in the given situation.

Semantics

Several authors have underlined that cost-effectiveness and cost-benefit analysis are the same, "effectiveness" being synonymous with "benefits".[5] However, though there are several points of similarity between them, several points of departure are also there and should be recognised as discrete techniques. Cost-effectiveness analysis owes its impetus for growth to the military applications in the United States, used to assist in choosing from alternative wagon system configurations and selecting products for military use. Evaluation of performance and cost trade-offs form an essential basis of cost-effective analysis which is defined as the quantitative examination of alternative prospective systems as to the potential trade-offs with regard to the effectiveness to be gained and costs to be incurred among the alternatives for the purpose of identifying the preferred system and its associated equipment, product, etc.

Both the terms 'cost' and 'effectiveness' are used in their broadest sense. Cost-effectiveness analysis itself may involve application of several other techniques dealing with individual facets of costs and effectiveness of various alternative courses of action. The primary question here is, as has been stressed earlier : what is the right level

5. Carl Heyel (Ed.) *The Encyclopaedia of Management*, Reinhold, New York, 1963, pp 121-125.

of resources to be provided for a particular activity? Contrarily, how should the resources be utilised for maximum effectiveness? Both the questions have relevance for decisional analyses in view of the fact that depending on the requirement of the job, the resources may be augmented either by diversion from other areas or by raising fresh resources. On the other hand, when managements have ample resources, the real concern changes its character, insofar as the most effective utilisation becomes the real problem. Thus, in the absence of anything better, managements are known to have put resources in fixed deposits, carrying interest at a rate of ten percent per annum whereas the best available alternative at the point in time and within the parameters of Government policy would not afford more than eight percent return on investment. Cost-effectiveness, therefore, provides a two-way mechanism of showing the way of most efficient resource utilisation and of protection against malutilisation.

Thus, it is apparent that rather different questions are asked and answered in the context of cost-benefit and cost-effectiveness analyses. Their contextualities are different and they show different ways of exercise of choice by management. The present discussion relates exclusively to an examination of cost-effectiveness in specific situations referred to earlier.

A Case Study

Charts I, II and III that follow give an indication of the cost-effectiveness of the research set-up referred to earlier as against what could have been if little higher costs were incurred, mainly in the form of balancing staff and equipment. The incremental costs could have been matched by ten times higher output in view of the high achievement orientation of the research staff but severely stunted in their effort to speed up output. The constraint of quality of the output was never there and higher speed would not have affected it adversely, to say the least. In the absence of output, even the barest minimum of expenditure on their salary etc., looked rather high and remained a talking point for others who either did not know what research meant or played the game intentionally, to discredit them. The dotted lines showing notional output and effectiveness are not exactly notional. These are based on the time

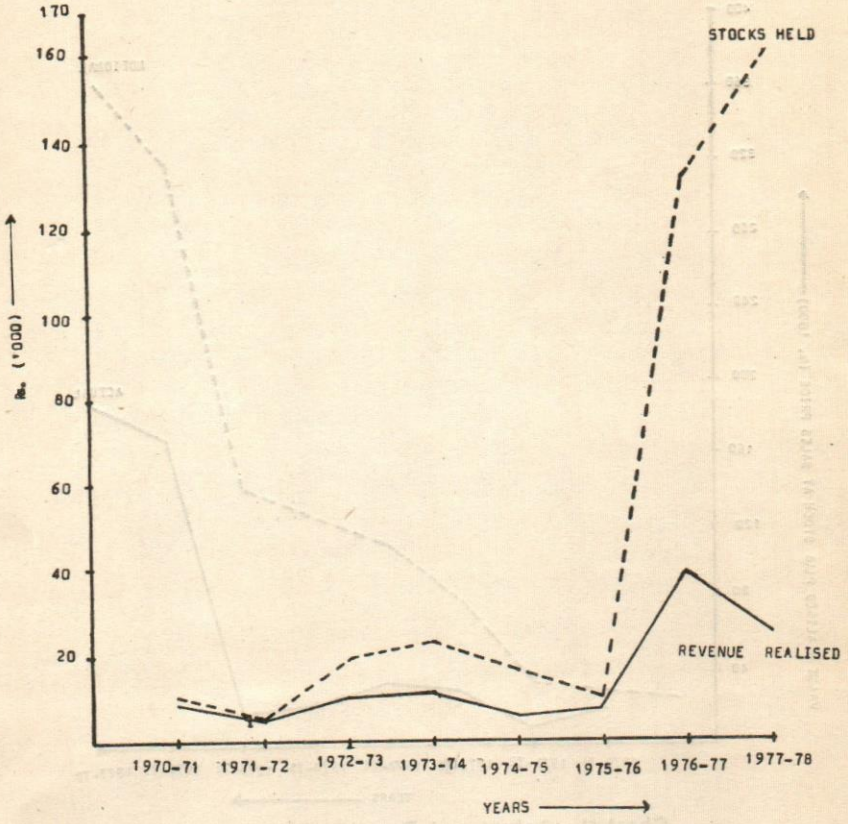

Chart I : Productive Analysis

actually taken where such facilities have been available. Even here, incurrence of cost or otherwise was also subject to factors like :

(a) Cyclostyling a draft research study took nine months, the entire work having been dependent upon the hospitality extended by colleagues in other departments making available stenographers and typists and the cyclostyling arrangements in spare time. Normal time should not have exceeded two months for the entire work. Even keeping one month as a margin, six months out of the actual nine months taken were waste of time, spelling further diseconomies in terms of lost motivation. The cost of this idle time due to delay was about Rs. 15,000 in all, enough

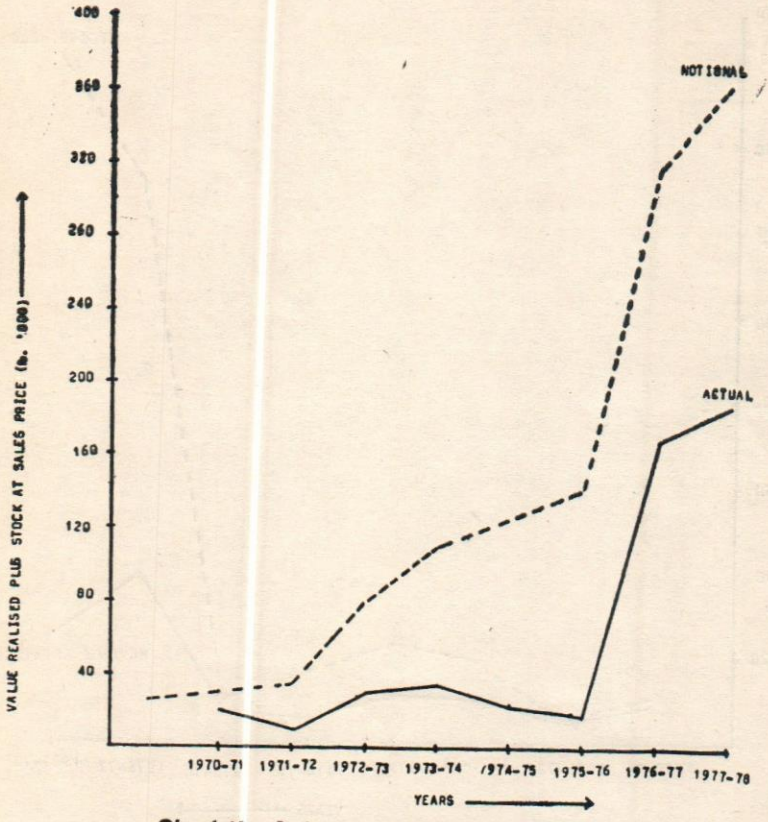

Chart II : Actual and Possible Results

to maintain two whole-time stenographers for an entire year. This diseconomy apart, aspersions were cast on the researcher for no fault of his own.

(b) The completion of studies took three times, the usual time that they would have taken or more, had all these minor balancing facilities been available. This is on the basis of the gestation period as estimated in the project proposals which were sanctioned by the authorities. Demotivations showed up in various forms, a serious and crippling one being that the research set-up had little power and discretion to find its wherewithals while opportunities slipped through the many pretexts offered. Here again, the cost of lost motivation apart, the constructive total loss incurred amounted to several thousands of rupees of con-

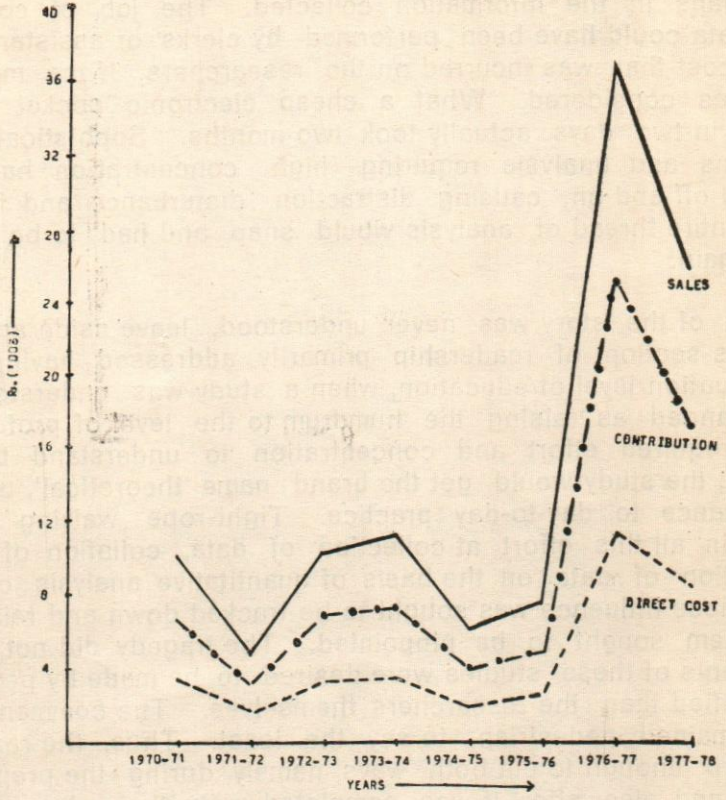

Chart III : Contribution Analysis

tribution arising out of the increased output; for while only one study could be brought out braving this rough weather, at least three more could have been completed during the same period of time. Thus, in the face of all these constraints, the researchers faced accusations and utter ignominy of various kinds. The whole story is laden with highly agonising experiences, reflecting on their capabilty.

(c) More than the foregoing instances, what was really a tiresome and bothersome tale was that the researchers had to collect the information from company records to do the primary calculations and to get the details in a presentable form, all by themselves, often after discussion with concerned executives on several occasions, even then leaving

serious gaps in the information collected. The job of collection of primary data could have been performed by clerks or assistants at one-third the cost that was incurred on the researchers, if the money value of time was considered. What a cheap electronic pocket calculator could do in two days actually took two months. Sophisticated, expert calculations and analysis requiring high concentration had to be postponed off and on, causing distraction, disturbance and frustration; for, the entire thread of analysis would snap and had to be picked up all over again.

This part of the story was never understood, leave aside appreciated. The cross-section of readership primarily addressed having no more than graduation level of education, when a study was understood easily, it was branded as 'raising the humdrum to the level of profundity' but when it required effort and concentration to understand the points developed, the study would get the brand name 'theoretical', underlining its irrelevance to day-to-day practice. Tight-rope walking was thus inherent in all this effort at collection of data, collation of data and interpretation of data on the basis of quantitative analysis of different factors whose influence was sought to be tracked down and relationships among them sought to be pinpointed. The tragedy did not end here. Assessments of these studies were desired to be made by people much less qualified than the researchers themselves. The comments in most cases remained pedestrian, to say the least. Thus, the razor's edge came sharp enough to cut both ways, namely, during the preparation of the work and also after it was completed notwithstanding the rough weather encountered at an earlier stage.

Determination of optimum expenditure and speedy decisions in this regard, as also clothing the researchers with adequate powers and authority, of course subject to due accountability, are aspects of cost reduction that have shown a high propensity to remain on paper or on bosses' lips rather than translated into action. Many a time, such schemes as may have been drawn do not come out of the bosses' drawers at all, but remain as talking points all along. On the positive side, a careful and sensitive approach to this can bring forth high cost-effectiveness. Sagging morale causes and contributes to fatigue. A softer touch, a good word, an encouragement, a sharing of problems and sympathy can bring back all the lost hopes. Coupled with some positive action by the bosses, cost-effectiveness can leap sky high

indeed. When the immediate neighbourhood remains not only indifferent to this need but also deliberately hostile, the silver lining has been provided by highly knowledgeable and internationally reputed foreign experts, whose good words and encouragement have acted as an elixir in moments of frustration and agony. Indeed, recognition has come much more from outside than from within, for reasons unknown to the researchers but most of the time sensed by them, namely, jealousy and ill-feeling. Politics, cliques, factionalism and pettiness marred the innate enthusiasm of the researchers teamed up by a far-sighted enthusiast who was no more in authority. His goodwill and gesture remained as a protective force all the while but mainly as an anti-negative rather than a positive one. This was not enough to keep the researchers on track.

In the context of these heavy odds, the quantum of output from the set-up was much more than satisfactory. In this regard, whether the level of attainment was satisfactory or otherwise and whether the cost incurred on the set-up was matched by effectiveness are questions that are to be judged on the basis of the following criteria :

(i) Output from similar organisations having a research set-up much larger and costlier.

(ii) Research products are not expected up the sleeves; the usual gestation period being given whether the output was poor, good or fair.

(iii) Since there is a correlation between speeding up and quality of research products whether the cognisable quality standards attained by these research studies were more than compensating the time actually taken or whether there was an extra cost of crashing which was not incurred.

(iv) By definition, research being extension of current knowledge, the studies so produced are not expected to sell like hot cakes. Even by this standard the performance was more than commendable as the figures would suggest.

(v) Different external proofs were available, attesting the high quality of the research products in terms of commendation from well reputed

experts as referred to earlier and awards and honourable mention made by external bodies; prescription of these studies as prescribed texts and recommended books of reference by several universities in this country; and commendation from knowledgeable analytical book reviewers.

Thus, while there is little doubt regarding the quality aspect of the studies completed by the set-up, an enthusiastic response from the clientele of professional readership is still awaited. There are several reasons for this. Specialised research effort means blowing up a relatively small area on the basis of either empirical proof or of logical arguments. The relevance of such studies for passing examinations remain always doubtful except by way of reference when the prescribed texts of universities and other professional institutions have coverage of much larger areas but not going as deep as the research studies do on its focussed area. However, over time the taste for such studies grows as a result of continuous exposure, debate on various issues and discussions on how the ideas or analyses presented in these studies can be implemented. Practicability of these studies in many cases is constrained by the provisions of the law and the traditional approaches to the concerned issue. Even practicability apparently has hierarchies in view of the fact that what the top boss of an organisation considers practicable may not be seen as such by people down below who invariably have a fragmented view of an organisation while the focal point of research study may be the organisation as a whole and aiming at sensitising the top management rather than those down below. By definition, the individual research studies encompass a defined and delimited area, as indicated in prefatorial notes to each of the studies. Market studies revealed a much greater acceptance by customers belonging to other professions and occupations than the particular profession for whose members these studies were intended. This has also been interpreted in the wrong way that members did not accept these studies while their reading habits and post-professional and continuing education left wide gaps. Whether these members were to be spoon-fed or they should be required to acclimatise themselves for this purpose is the major issue. □

Production Planning of Large Complex Products

R. K. Sachdeva*

Introduction

Production Planning situations generally discussed are of two types : Job Shop Production and Mass Production.

In job shop production situation, the items are manufactured against specific orders while in mass production, the items are produced for stock to be sold later. In both the situations, the standard methods of job shop scheduling and batch production respectively are adopted. Where a number of identical items are to be manufactured, the economic batch size of production, taking into consideration the set up time of machine and the inventory cost is worked out.

Mass production of complex products consisting of a large number of components as in automobiles is broken up to apply the same techniques for its various components. The components are generally manufactured in batches of economic sizes and then assembled on the assembly line which is balanced in order to minimise the idle time at various stations in waiting for the next product to arrive from the previous working station.

The approach is successfully applied to production of a large number of identical products like motor cars, television sets, etc. The problem of production planning becomes more complicated when the product consists of large number of components and, at the same time, each product manufactured is different from another, viz., in the production of ships, large-size transformers, etc. They may have to be manufactured against specific orders, the products-mix varying from time to time. Each unit may differ in capacity and certain other design features. A common production facility is used for the manufacture of these products, which consists of hundreds of machines and men. A single product unit may consist of more than thousand components, some of which are purchased from outside and others manufactured within the company.

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The Problem

No standard methodology for the production planning of such complex products has so far been evolved which could take into consideration the deadlines for supply of the various products, the utilisation of the existing and long-term planning of production capacity and the volume of in-process inventories of the semi-finished products built up on the shop-floor. Use of project planning techniques like PERT/CPM have sometimes been recommended in such situations by drawing analogies from the project planning situations. The manufacture of each product is considered as a project as it consists of a large number of interrelated activities involved in the manufacture of its various components, sub-assemblies and the final assembly of the product. Apart from these similarities with the construction project, there are distinct points of differences between this production situation and that of a construction project. Construction projects are of limited duration and the primary concern in their management is to minimise this duration so that the benefits of the project can be reaped earlier. Since the project is of a limited duration, no permanent assets of machinery and manpower are built up. These resources are generally hired for a limited period to meet the needs of the project. The emphasis is on the completion of the project rather than the management of construction resources.

A company engaged in the manufacture of large complex products has to build up a permanent set of assets in their plant. Apart from the fixed assets of plant and machinery, they have to invest working capital on the inventories of semi-finished components and raw materials in stock. The assets of machinery and manpower become permanent and hence non-flexible and cannot be hired and fixed to meet the product needs of different products. Materials may not impose such non-flexibility but the working capital invested in them is quite substantial. At times, it may be more than the total fixed capital. Moreover, short-term capital required for materials is generally available at a higher rate of interest than long-term credit. So, the minimisation and levelling of working capital requirement is quite important. While meeting the time schedule of delivery committed to the consumers, the primary concern in such a situation is to achieve maximum return on the capital employed in the resources. Due to these differences from the construction project, the use of PERT/CPM in the conventional manner would not lead to very useful results.

This paper is the outcome of the author's involvement as a consultant in a study of a firm manufacturing large-size transformers in the range of 20 MVA to 400 MVA. The recommendations and their successful applications in the plant are dealt with in subsequent paragraphs.

Existing Practice

Before the study, the company was making aggregate schedules of production showing the target for the completion of the six major stages in the production of transformers carried out in six shops and the overall completion target for each transformer. This was based on rough estimates of the time required to process the transformer in each shop on the basis of the size of the transformer. The detailed scheduling of the activities was left to the shopfloor people on a day-to-day basis. The interaction of the activities of various transformers was not studied, with the result, that activities were executed as and when the resources were found available. This, often, resulted in delays in the execution of the activities. The performance was reviewed in regular weekly production meetings, when the cases for delay were discussed, and usually, the schedules had to be revised.

The top management of the company was not satisfied with the existing practice and felt that the existing production capacity was not fully utilised due to lack of co-ordination between various activities. The in-process and raw material inventories were very high and the total investment in working capital, by and large, was more than the total fixed assets in land, buildings, plant and machinery. An attempt was also made to reduce the inventories by installing IBM inventory control system on computer.

Objective

The detailed scheduling of production activities by the Production Planning Department was recommended to achieve the following objectives :

(1) Optimum utilisation of existing machinery and manpower resources of the company.

(2) Planning for additional resources.

(3) Ensuring availability of materials as per production schedule, while maintaining the minimum required stock of raw materials.

(4) Planning maintenance of machinery during spare time.

(5) Bringing down in-process inventory in the plant so as to minimise the need for working capital.

(6) Booking of selective orders most profitable to the company.

(7) Meeting delivery schedules committed to the customers.

(8) Sub-contracting of components in time.

It was also decided to make one firm monthly schedule for purposes of its execution on the shopfloor and five tentative monthly schedules for the next five months for purposes of procurement of materials, sub-contracting of components, setting up additional resources, planning of finances, etc.

Methodology

(a) Work-breakdown Structure

The procedure followed in the preparation of schedules was based on Programme Evaluation & Review Technique, commonly used for planning and monitoring the progress of projects. The technique was adopted to suit the needs of production planning in the company.

The first step in the preparation of PERT chart for a project is the work breakdown structure of the entire project. The work breakdown structure aims at breaking the entire project into major groups of work or components and then sub-groups and, finally, into small independent activities of work which once started can be finished without interference from other activities of the project.

In the present study, the work comprised manufacture of a number of

transformers, one after another. No beginning or end of the work, like in a project, could be identified. It was a continuous flow of work with some transformers being completed and leaving the shop floor and at the same time, some new ones entering the shop floor. During the six months period under study, as many as 24 transformers of various sizes were under different stages of production on the shop floor. The production planning of a continuous activity like this had to be time bound—like in this case, one month firm plan and five months, tentative plan unlike in project where it has to be work bound—from the beginning to the end of the project. It could not be determined in advance, as to how many of the transformers would qualify for production during the next six months period and which of the activities of those transformers would be completed during the period.

It was, therefore, decided to prepare one PERT Chart separately for each transformer as soon as the broad design work for that transformer was completed whether or not it qualified for production during the plan period. The chart kept ready could be used for the scheduling of activities as and when necessary.

Broadly speaking, the manufacture of a transformer consisted of six major tasks to be carried out in six shops of the plant :

(i) Coil winding

(ii) Core Making

(iii) Tank Making

(iv) OLTC Making (On Load Tap Changer)

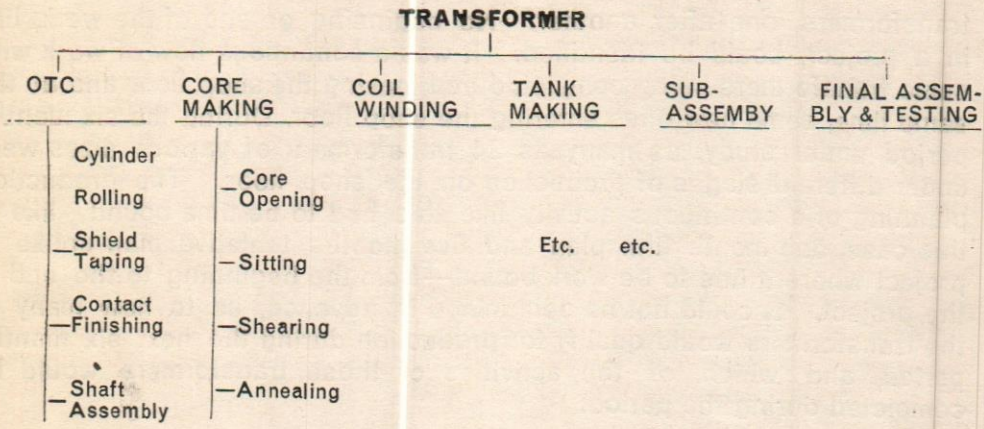
(v) Sub-Assembly

(vi) Final Assembly & Testing.

The work in each shop was broken up into small independent activities so that the manufacture of entire transformer consisted of about 200 activities or more, depending on the design of the transformer.

(b) Time Estimates

It is imperative that, time for each individual activity is estimated. Single or three time estimates are used in PERT, depending on the type of project and the previous experience available for the activities. In production planning situations, activity timings can be estimated fairly accurately, based on previous experience on similar activities. Time standards



fixed by Industrial Engineering techniques are easily available. Hence, one time estimate only need be used. Sometimes, the exact volume of activity may not be available at the time of preparation of PERT chart pending detailed design. A rough estimate is sufficient for the tentative plans which can be replaced with the accurate one after detailed design before the activity qualifies for the firm plan.

(c) Resource Requirement of Cash Activity

An activity may be machine-oriented or man-oriented depending on the nature of the activity. For instance 'winding' can be considered as machine-oriented and the resources requirement for the same is the winding machine. The operator can be assumed to be available along with the machine. Machine availability is considered as the deciding factor. Welding for tank making can be considered as man-oriented as each welder is consigned a welding machine which is always available with him. Here, a welder is considered as the resources requirement. However, there may be different categories of welders, viz., skilled semi-skilled welder etc.

In each shop, 10-15 such resources were identified and the quantity of each resource (e.g., one Fitter and two Helpers) required during the execution of each activity was specified. Apart from men and machine resources, non-stock items of material were also to be considered as resources since it was important to plan the timely procurement of such materials to avoid any interruptions in production while keeping the stock of such items at the minimum level. The stock items of material were

classified according to ABC analysis and normal rules of Re-order Level and Economic Order Quantity applied to them.

(d) Preparation of Network

The activities were then arranged according to their logical or technological sequence to form a Network diagram as per the normal rules of PERT. As explained earlier, since it was not known before the analysis was completed, as to how many transformers and which activities of those transformers would qualify for scheduling during the next six months, networks were prepared separately for each transformer and kept ready as soon as the broad design for that transformer was completed. Further refinements could be made in future updatings as and when detailed drawings were ready. One such network diagram is shown here. It was observed in practice that there were some basic activities in the manufacture of a transformer which were present in transformers of all specifications. Due to this, the basic structure of the network remained more or less the same. It was only necessary to make minor modifications in the structure from one transformer to another. This made the task of making one network for each transformer much faster. The time and resource requirements of the activities, however, depended on the size of the transformer and had to be estimated separately.

(e) Time-Schedule Bar Charts (Transformer-Wise)

After the preparation of Networks, Time-Analysis was carried out on them for each transformer separately to work out the earliest and latest time for each event, total completion time of the transformer and earliest and latest start and finish time of the activities. However, some assumptions were implict in this analysis; that all the resources required by an activity were available when the activity was planned to be executed; that each transformer was being manufactured separately and had no relationship or clash with the manufacturing process of other transformers. Obviously, these assumptions were not true. But transformer-wise time analysis was the only first step which provided the basis for further resource analysis where these clashes were considered and a realistic shop-wise schedule prepared.

After the time analysis on the network diagram, the results of the analysis were transferred to a bar-chart to make it more convenient for reference.

The normal rules of network-based Bar Charts were followed. A firm line was used to represent the early schedule of the activity, followed by dotted line to show the total float of the activity.

(f) Work out (i) Transformer Float (ii) Shop Float within Transformer (iii) Activity Float within Shop

Having completed the transformer-wise time-analysis, the plant resources were allocated to the activities as and when they fell due for scheduling. Since the activities of each transformer were linked together by the technology of manufacture of the transformer in a logical sequence, the networks were prepared transformer-wise to represent that sequence and the time analysis was also carried out transformer-wise. But when it comes to shop resources, the activities of the transformer were divided into winding, core-making, tank-making, etc., and had to be carried out in the respective shops, i.e., winding shop, core-making shop, tank-making shop, etc. An activity of the winding shop does not have to share resources with another activity of the core-making shop. To that extent, they could be scheduled independently in each shop without any conflict of resources with the activities of the other shops. Instead, it had to compete for resources with other activities to be carried out in the same shop, whether belonging to the same transformer or any other transformer. The problem of resource analysis was basically that of allocating a limited set of resources available in one shop to all the activities to be executed in that shop by contributing equally to various transformers. So the unit of resource analysis had to be a shop and not a transformer.

The shop-wise allocation of resources involved determination of inter-activity priorities of all the activities competing for resources in that shop. As discussed earlier, the objective of production planning is to achieve minimisation of inventories and the optimum utilisation of resources. This was achieved by completing the in-process transformer in the minimum possible time and meeting the time schedule committed to the customer while keeping all the resources engaged in productive activities. Hence, the priority of an activity *vis-a-vis* other activities had three components :

(i) The expected completion of the transformer to which the activity belonged *vis-a-vis* the target date committed to the customer. For example, in the sample network, the expected completion of the

transformer was 107 days after it was started. The position was to be reviewed on the 1st of January when the activities of this transformer were yet to be taken up for scheduling. The target for the completion of transformer was 31st October of the same year. The number of working days available were 255. So, the transformer float was $255 - 107 = 148$ days which formed one of the components in deciding the priority of all the activities of this transformer.

(ii) The expected completion of the activities belonging to a transformer to be carried out in a shop *vis-a-vis* other activities of this transformer to be carried out in other shops. For example, in the sample network, the activities of the core-shop till Testing (30-31) and Disassembly of Upper Yoke Clamps and Upper Yoke Laminations (31-56) were expected to be completed in 35 days while the activities of the winding shop till assembly (55-56) along the critical path when the core was required were expected to be completed only in 68 days. So, the activities of the core-shop had an extra float of $68 - 35 = 33$ days in this shop within the transformer. This formed the second factor in deciding the priority of this activity.

(iii) The expected completion of an activity *vis-a-vis* other activities of the same transformer in the same shop. This was the normal activity float taking a portion of network for one shop as an independent project. For example, the activities of the core-shop in the sample network were expected to be completed in 35 days. Assuming 35 days as the latest completion date for the core, the activity of annealing (20-22) had a float of 4 days.

(g) Resource Schedule Bar-Charts : Shop-wise

As discusssed earlier, the unit of resource scheduling was a shop and a separate schedule had to be prepared for each shop. The total set of resources available in the shop were listed for allocation to various activities. The allocation was made in the order of priority of the activity till all the resources were exhausted. The remaining activities were deferred till all the higher priority activities were scheduled.

The last two factors, viz., the 'shop float within transformer' and 'activity

float within shop' were additive and combined to form the 'activity float within transformer'. Since transformer was the unit of manufacture to be delivered to the customer, shop-wise completion of the transformer activities were significant only to the extent that they contributed towards the completion of the transformer. But the completion of the transformer was a productive achievement in the sense that it could be shipped to the customer and the inventory cleared from the shop floor. It was, therefore, important to complete the transformer as soon as possible, once it was started irrespective of the date of delivery provided the customer was prepared to accept it on an early date. To provide this factor of working capital, the transformer float had to be modified by a factor F ranging between ϕ and 1. Hence

Priority float of activity =

Activity float within shop + shop float within transformer + F × Transformer float.

F=O if the value of transformer was very high and the customer was prepared to accept it as soon as possible.

F=1 if the value of transformer was very low or the customer was not prepared to accept it before a specified date.

O<F<1 for other cases. Higher the value of transformer, lower the value of F.

(h) Machine Loading Charts

The utilisation of each resource on each day were worked out on the bottom of Resource Schedule as in the sample shown. This proved helpful in future planning of the resources. Similarly, machine loading charts for the major machines were prepared to get an idea of the extent of utilisation of each machine as is shown for Grit Blasting in the sample chart. This also ensured that the resources were not exceeded in the preparation of schedule and, that enough time was provided for maintenance, etc. The capacity utilisation of the machine would get recorded and the scheduling of preventive maintenance could be carried out in the spare time without keeping the jobs waiting.

(i) Planning for Materials

As mentioned earlier, the raw materials were divided into two major categories : (a) Stock items, and (b) Non-Stock items.

The stock items were those which were regularly consumed for most of the transformers and ready stock had to be kept for them. The amount of stock to be kept was determined by the average consumption of the item, based on the past experience and was not related to the production schedule. The normal techniques of inventory control were applied to these items. They were further classified into A, B and C categories and the economic order quantity and reorder levels worked out on the basis of average consumption.

The non-stock items were those which were not regularly used but were required specifically for some transformers. Such items were normally not kept in stock, but had, be procured when required during the manufacture of the transformers. When the detailed activity schedules were not prepared, the exact requirement of such items could not be ascertained with the result that some of these items were procured well in advance, adding to the inventory level, while emergency purchases had to be resorted to for some others. With the preparation of detailed schedule and the resource requirements of each activity including non-stock items of raw materials, the exact periodical requirements of these Items could be worked out and communicated to the Purchase Department.

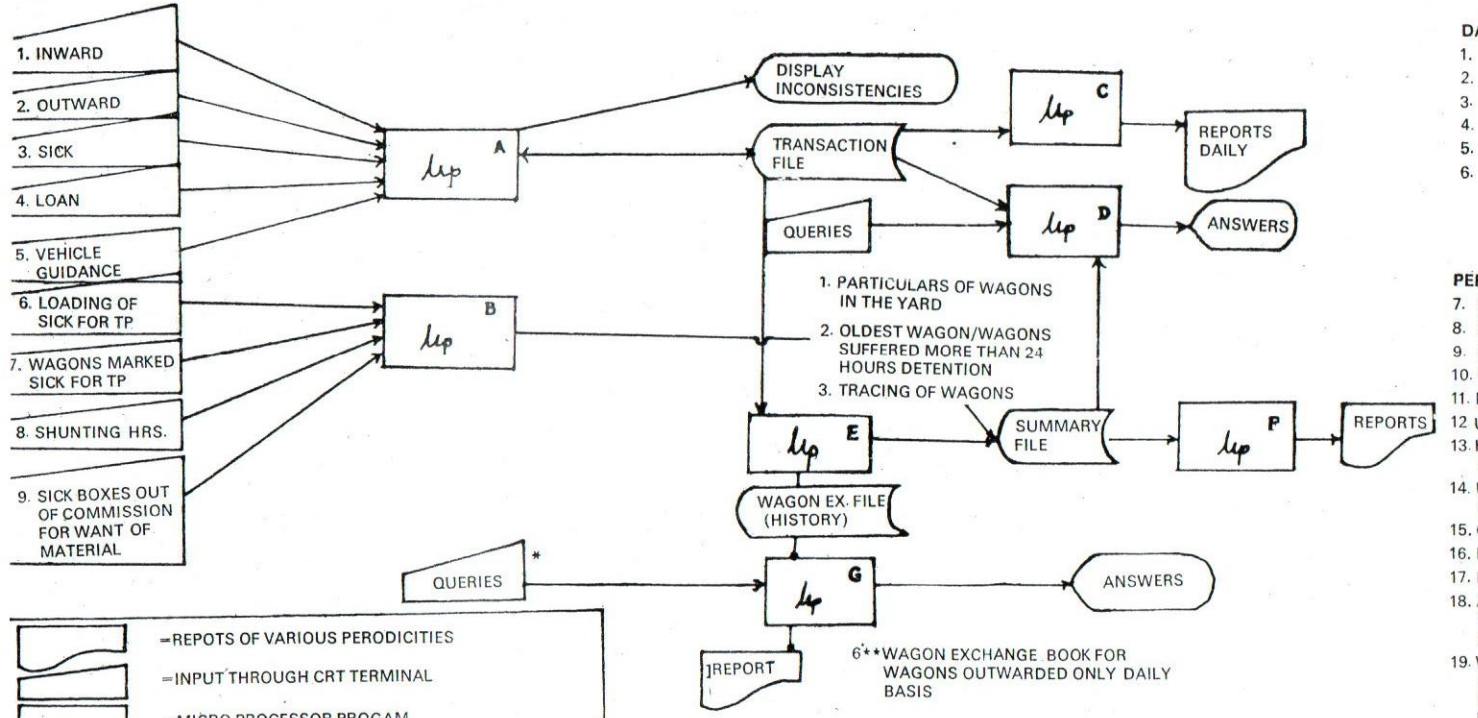
(j) Monitoring and Control

The monthly firm scheduled bar-chart was supplied to the shop-floor and displayed in the office of the Shop Superintendent for ready reference. The activities were executed according to this schedule and the daily progress was recorded on the chart with coloured pencil at the end of each day. On the last day of the month, the progress was communicated to the Production Planning Department for preparing the next month's firm plan. The firm plan for the next month was expected to be prepared by Production Planning in about 4-5 days and supplied back to the shop-floor. A ten-day extension was provided on the monthly chart to provide for the updating time.

Conclusion

By and large, the situation of production of large complex products is peculiar in its own way in the sense that the conventional methods of production planning are not applicable to it. The situation being quite different from that of a project, the techniques of PERT/CPM in their conventional manner treating each product as an independent project and conducting time analysis and resource analysis for each product will not prove to be very useful. However, the basic concepts of PERT/CPM suitably adapted to the situation can help to evolve very effective production planning methodology leading to higher productivity through better utilisation of plant capacity and bringing down inventories. □

Exhibit IV : Processing System Proposed



*1. HEAVY/AVERAGE DETENTION
2 TRACING OF WAGONS & QUERIES WAGONS OUTWARDED MORE THAN 3 DAYS BACK

DAILY REPORTS

1. UP BALANCE
2. DOWN BALANCE
3. COPS
4. PROFORMA F. E.
5. LOCO VANS
6. **

PERIODIC

7. FAIR STATISTICS (10 DAYS)
8. FAIR STATISTICS (MONTHLY)
9. SHUNTING HR REPORT (10 DAYS)
10. NO. OF WAGONS/SHUNTING HR (MONTH
11. MARSHELLED BOX RAKES (MONTHLY)
12. UNCONNECTED OIL TANKS (MONTHLY)
13. KKF/SHALIMAR Q.T.S. WAGONS MOVEMENT (10 DAYS)
14. UTILIZATION OF TANK WAGONS OTHER TI POL—BRC BASE (10 DAYS)
15. CONTAINER SERVICE ASV/OCB/ASV (10 D
16. MOVEMENT OF VOTS—BRC BASE (MONTH
17. MOVEMENT OF VOTS—OTHER BASE (MON
18. AVG. DETENTION FOR VARIOUS CATEGOF OF WAGONS SUCH AS UP : THROUGH : DN : THROUGH : (10 DAYS)
19. WAGONS SUFFERED MORE THAN 7 DAYS DETENTION—MONTHLY THIS REPORT IS I PRESENT IN THE CURRENT SYSTEM & IS A PROPOSED ADDITION.

Exhibit I : Flow Diagram of the Existing Input Information and the Reports Compiled

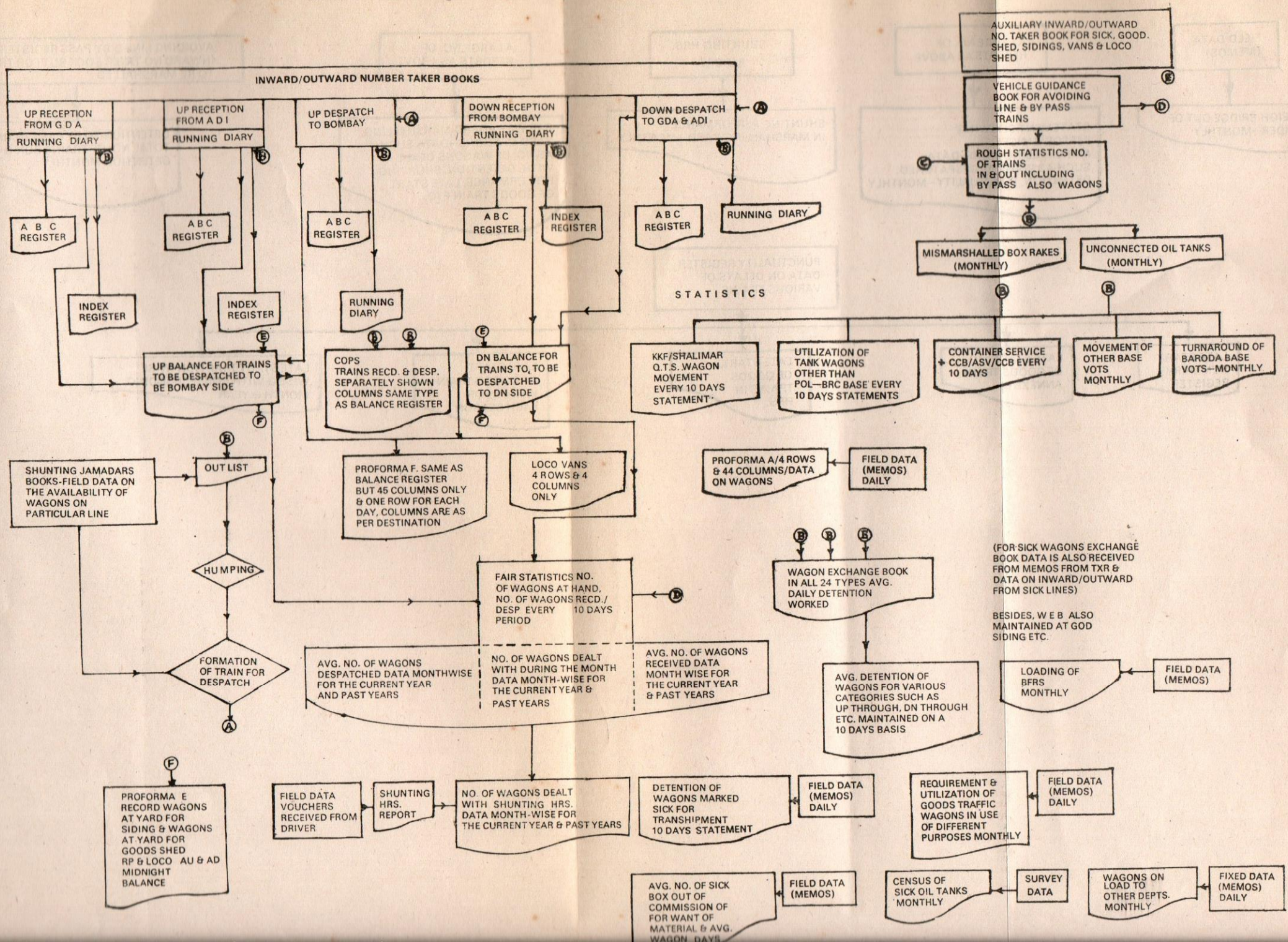
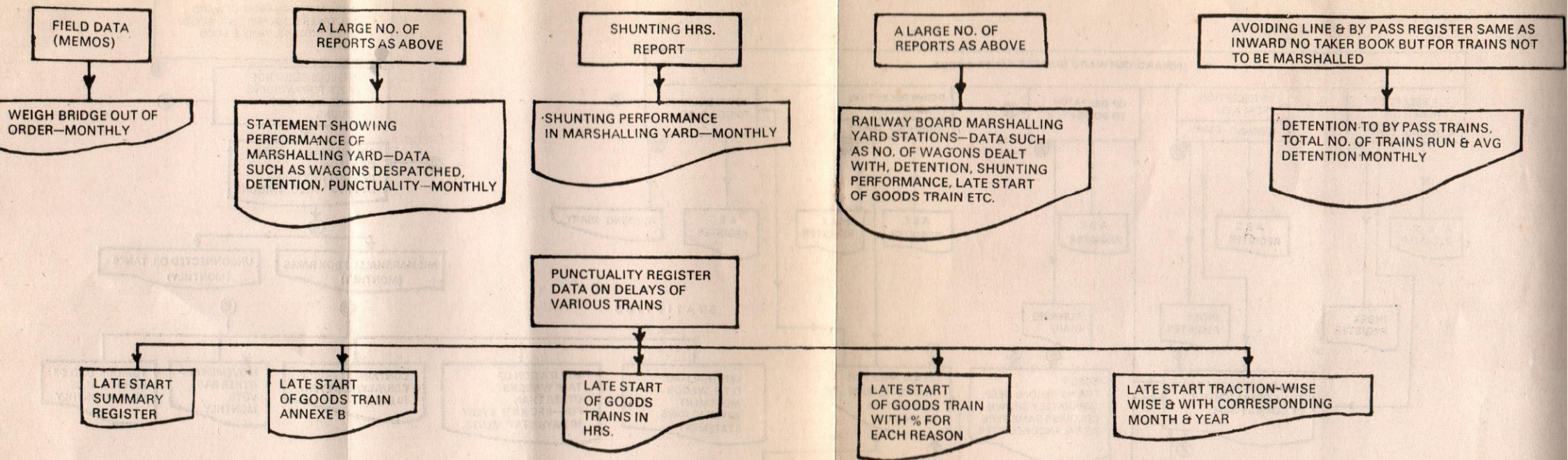


Exhibit I Contd : Other Statistics



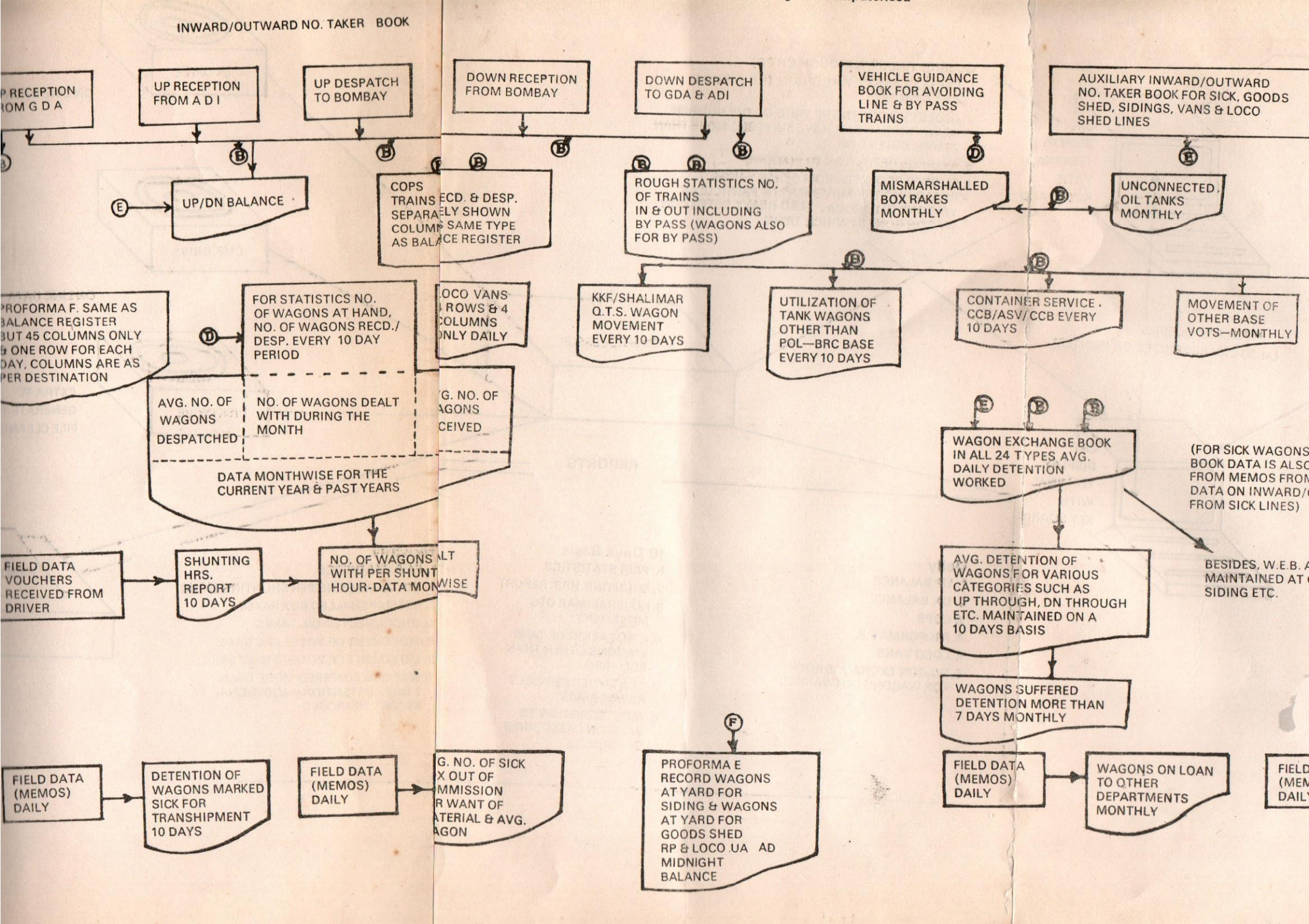

INWARD/OUTWARD NO. TAKER BOOK
P RECEPTION ROM G D A
UP RECEPTION FROM A D I
UP DESPATCH TO BOMBAY
DOWN RECEPTION FROM BOMBAY
DOWN DESPATCH TO GDA & ADI
VEHICLE GUIDANCE BOOK FOR AVOIDING LINE & BY PASS TRAINS
AUXILIARY INWARD/OUTWARD NO. TAKER BOOK FOR SICK, GOODS SHED, SIDINGS, VANS & LOCO SHED LINES
UP/DN BALANCE
COPS TRAINS SEPARA COLUM AS BALA
ECD. & DESP. LY SHOWN SAME TYPE CE REGISTER
ROUGH STATISTICS NO. OF TRAINS IN & OUT INCLUDING BY PASS (WAGONS ALSO FOR BY PASS)
MISMARSHALLED BOX RAKES MONTHLY
UNCONNECTED OIL TANKS MONTHLY
PROFORMA F. SAME AS BALANCE REGISTER BUT 45 COLUMNS ONLY ONE ROW FOR EACH DAY, COLUMNS ARE AS PER DESTINATION
FOR STATISTICS NO. OF WAGONS AT HAND, NO. OF WAGONS RECD./ DESP. EVERY 10 DAY PERIOD
OCO VANS ROWS & 4 COLUMNS NLY DAILY
KKF/SHALIMAR Q.T.S. WAGON MOVEMENT EVERY 10 DAYS
UTILIZATION OF TANK WAGONS OTHER THAN POL—BRC BASE EVERY 10 DAYS
CONTAINER SERVICE CCB/ASV/CCB EVERY 10 DAYS
MOVEMENT OF OTHER BASE VOTS—MONTHLY
AVG. NO. OF WAGONS DESPATCHED
NO. OF WAGONS DEALT WITH DURING THE MONTH
G. NO. OF AGONS CEIVED
DATA MONTHWISE FOR THE CURRENT YEAR & PAST YEARS
WAGON EXCHANGE BOOK IN ALL 24 TYPES AVG. DAILY DETENTION WORKED
(FOR SICK WAGONS BOOK DATA IS ALSO FROM MEMOS FROM DATA ON INWARD/ FROM SICK LINES)
FIELD DATA VOUCHERS RECEIVED FROM DRIVER
SHUNTING HRS. REPORT 10 DAYS
NO. OF WAGONS WITH PER SHUNT HOUR-DATA MON LT WISE
AVG. DETENTION OF WAGONS FOR VARIOUS CATEGORIES SUCH AS UP THROUGH, DN THROUGH ETC. MAINTAINED ON A 10 DAYS BASIS
BESIDES, W.E.B. A MAINTAINED AT SIDING ETC.
WAGONS SUFFERED DETENTION MORE THAN 7 DAYS MONTHLY
FIELD DATA (MEMOS) DAILY
DETENTION OF WAGONS MARKED SICK FOR TRANSHIPMENT 10 DAYS
FIELD DATA (MEMOS) DAILY
G. NO. OF SICK X OUT OF MMISSION R WANT OF TERIAL & AVG. AGON
PROFORMA E RECORD WAGONS AT YARD FOR SIDING & WAGONS AT YARD FOR GOODS SHED RP & LOCO UA AD MIDNIGHT BALANCE
FIELD DATA (MEMOS) DAILY
WAGONS ON LOAN TO OTHER DEPARTMENTS MONTHLY
FIELD (MEM DAIL

Exhibit III : The Proposed System

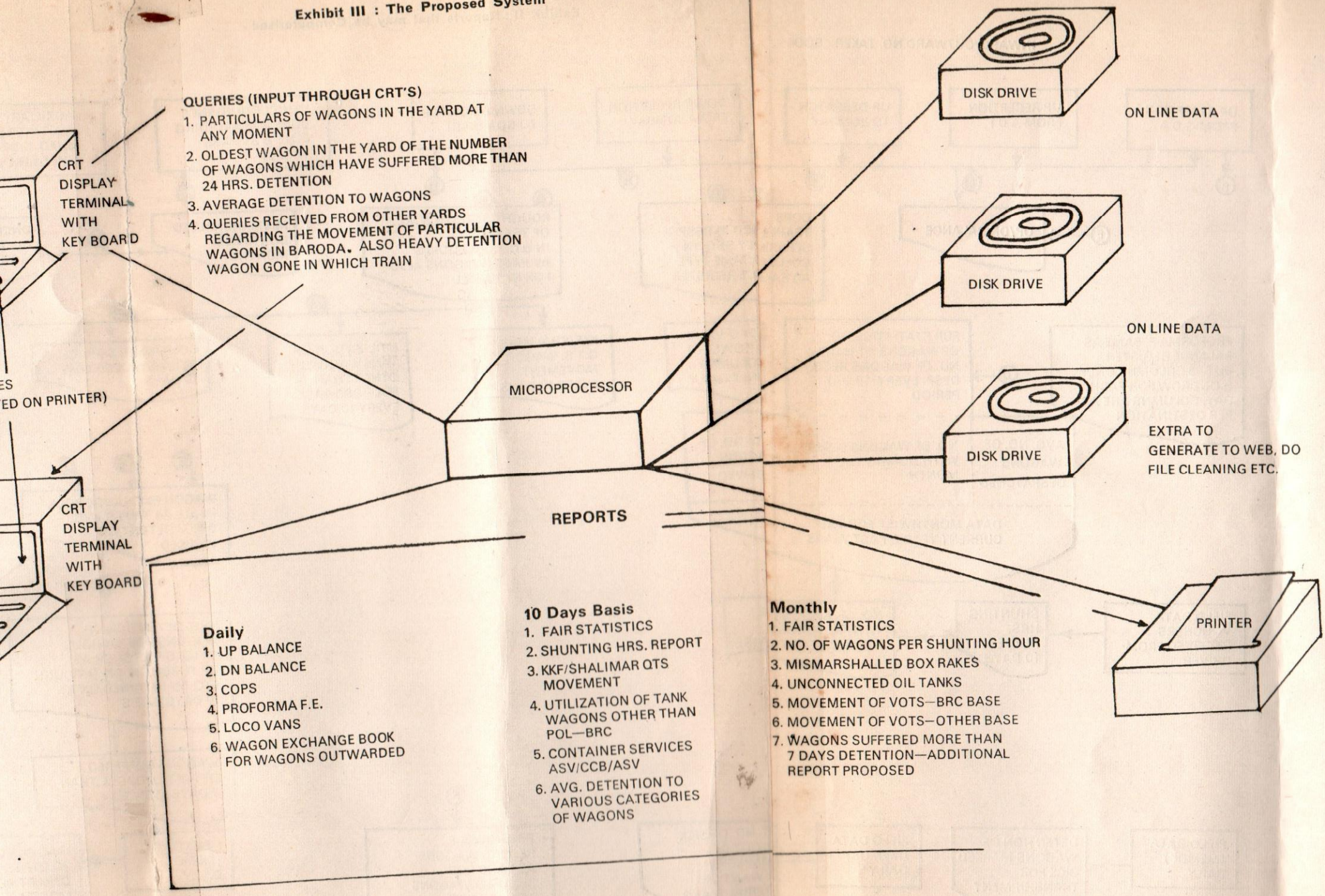


Exhibit 3 : Goal Programming Results for Rural Development and Em

	3.22			9.22	7.5	59.2	79.2	
NUMBER			1.5	8.76	7.5	66.1	83.86	
OF	4.3		13.25	10.00	7.5	30.7	65.67	
INDUSTRIES			14.48	11.27	7.5	28.31	61.57	
	4.62	6.25	13.33	12.72	7.5	6.67	51.09	

Sl. No.	Activities	IND 1	IND 2	IND 3	IND 4	IND 5	IND 6	IND 7	Total	CASE A Priorities	CASE A Constraints	CASE A RHS given	CASE A Result	CASE B Priorities	CASE B Constraints	CASE B RHS given	CASE B Result
1.	Investment required (Rs)	1,000	700	650	400	2,000	1,200	700			⩾	80,000	53.457		⩾	80,000	57,169
2.	Skilled persons	4	3	3	1	5	3	2			⩽	150	150		⩽	150	150
3.	Unskilled persons	8	10	9	5	10	5	4		IV	⩾	400	358	I	⩾	430	336
4.	Pollution P.P.M.	40	120	120	140	130	70	70			⩽	6,000	5,446		⩽	6,003	6,000
5.	Power Consumption KWH	6	5.5	4	2	8	6	4		I	⩽	300	262	II	⩽	300	277
6.	Total Return (Rs)	80	63	58.5	40	240	108	49		II	⩾	6,000	5,487	III	⩾	6,050	5,484
7.	Local Investment (Rs)	200	210	195	160	200	180	100			⩾	10,000	8,931		⩾	10,090	8,753
8.	Social cost (Rs)	20	15	12	10	30	20	10			⩾	1,000	918		⩾	1,000	916
9.	Total	1	1	1	1	1	1	1	—1		=	0.0	0.0		=	0.0	0.0
10.	Cotton Product 1	7									=	40	32.3		⩽	40	0 0
11.	Cotton Product 2		8								=	50	50		⩽	50	0.0
12.	Cotton Product 3			6							=	10	0.0		⩽	10	0.0
13.	Cotton Product 4				3						=	40	40		⩾	40	43.4
14.	Sugarcane Product 1					5					=	70	63.6		⩽	70	56.4
15.	Sugarcane Product 2						4				=	30	30		⩽	30	30
16.	Sugarcane Product 3							3			=	20	20		⩽	20	85
17.	Cotton raw material locally available, units	5	5	5	3					III	⩾	100	94.34		⩽	100	43.4
18.	Sugarcane raw material locally available units					4	3.5	3		III	⩾	100	97.14		⩽	100	156.3
19.	Cotton raw material locally not available units	2.5	3.5	1.1							⩽	40	33.42		⩽	40	0.0
20.	Sugarcane raw material locally not available units.					1.5	0.7	0.1.			⩽	25	25		⩽	25	25

CASE C				CASE D				CASE E			
Priori-ties	*Cons-traints*	*RHS given*	*Result*	*Priori-ties*	*Cons-traints*	*RHS given*	*Result*	*Priori-ties*	*Cons-traints*	*RHS given*	*Result*
	⩾	80,000	60,073		=	80,000	73,390	I	=	80,000	72,139
	⩽	200	164.3		⩽	200	200		⩽	200	200
I	⩾	400	360.2	I	⩾	400	397	II	⩾	400	392.5
	⩽	6,000	6,000		⩽	6,500	6,500		⩽	6,000	6,000
II	⩽	300	300		⩽	400	382 5		⩾	0.0	375
	⩾	6,000	5,587		⩾	6,000	6,211		⩾	6,000	6.184
	⩾	10,000	9,396		⩾	10,000	9,951		⩾	10,000	9,764
	⩾	1,000	975		⩾	1,000	1,089		⩾	1.000	1,084
	=	0.0	0.0		=	0.0	0.0		=	0.0	0 0
	⩽	30	30		⩽	30	0.9		⩽	30	22.6
	⩽	50	0.0		⩽	50	0.9		⩽	50	0.0
	=	10	0.0		=	10	0.0		=	10	0 0
III	⩾	40	39.7		⩾	40	4.5		⩾	40	0.0
	⩽	50	50		⩽	50	43.8		⩽	50	46
	⩽	30	30		⩽	30	30		⩽	30	30
III	⩾	50	92.1		⩾	50	198.3		⩾	50	177.7
	⩾	100	61.2	II	⩾	100	4.5		⩾	100	16.1
	⩽	100	158.3	II	⩾	100	259.6	III	⩾	100	241
	⩽	50	10.7		⩽	50	0.0		⩽	50	8
	⩽	25	23 3		⩽	25	25		⩽	25	25

Optimum Location of Warehouses in A Physical Distribution System

A. D. Gupta* & R. K. Mathur**

Introduction

This paper is based on a study conducted in a section of a giant public sector undertaking engaged in mass movement of passenger and goods traffic. There are eighteen depots which receive and store about 30,000 items from 1200 suppliers and subsequently despatch them to 800 demand points. Each item is stored at some of the eighteen available depots, the criterion of selection of such 'main' depots being their proximity to the sources of supply. The material is then transported to remaining 'subsidiary' depots for issue in their respective territory. Thus for each item, there are some main and subsidiary depots and each depot serves the requirement of its demand zone. The number of demand zones is the same as the number of depot sites. Imprest material is issued from a depot to a number of demand points (e.g., running sheds, train examining sheds, etc.) lying in its territory. Each imprest holder is issued material as a standing advance for day to day requirements for the purpose of repair and maintenance of rolling stock. However, the selection of main and subsidiary depots for each item has not been done in a scientific or systematic manner.

The present study was undertaken with the following objectives :

a) To decide optimum number and location of main depots or warehouses.

b) To assign remaining depots to main depots.

The problem has been reduced to a depot location problem for each item. The limitation of the study lies in considering only the cost of transportation. However, the approach can be extended further by taking into account the inventory cost and administrative expenses. The results for only one item 'Heavy Axle Lubricating Oil' are reported in this paper since this item occupies the most significant place in ABC analysis.

*Mr. Gupta is Member of Faculty, Indian Institute of Technology, New Delhi and **Mr. Mathur has been selected in IAS.

Assumptions

1. All the eighteen potential warehouse sites are fixed in number and location. No change is permissible since it would require major shifting.

2. For heavy axle oil, there is no space restriction at any of the eighteen potential warehouse sites, i.e., each site can store entire oil supply for the public sector undertaking. When a number of items are considered, this assumption may become questionable due to practical limitation of storage space.

3. No other mode of transportation apart from railways is permissible (all depots have railway sidings).

4. The freight charge depends only on the shortest track distance and amount of material transported. It does not depend upon whether the tank wagon is fully or partially loaded.

Model Formulation

Eilon and Watson Gandy [1] suggest that the approaches to depot location can be categorised into two groups :

(a) Infinite Set Approach : It assumes that a depot may be positioned anywhere in the particular area being examined, i.e., there are infinite number of possible locations.

(b) Feasible Set Approach : It assumes that only a finite number of known feasible locations for depot sites is available, so that the search is confined to a choice from this feasible set.

For the problem under study, infinite set approach is unrealistic, because the depot locations are finite and fixed. Three different solution approches have been developed to search for the sites from a finite set :

(i) Mathematical Solution,

(ii) Simulation Approach,

(iii) Heuristic Approach.

Heuristic programming algorithm for warehouse location suggested by Shannon and Ignizio [2] has been applied to arrive at preferred solution to the given transhipment problem.

It is required to put K warehouses in N possible locations ($K \leqslant N, j = 1, 2, 3, \ldots\ldots N$). There are M demand sites with a demand of Q_i per time period ($i = 1, 2, 3, \ldots\ldots M$).

$$Y_j = \begin{cases} 1 \text{ if allocate a warehouse to location } j \\ 0 \text{ otherwise} \end{cases}$$

$$Z_{ij} = \begin{cases} 1 \text{ if demand } Q_i \text{ is allocated to warehouse } j \\ 0 \text{ otherwise} \end{cases}$$

D_{ij} = distance from demand centre i to warehouse location j

a_{ij} = cost coefficient of supplying demand Q_i to demand site i from warehouse location j $= (Q_i \cdot D_{ij})$

$A = (a_{ij})$ = matrix M · N of cost coefficients

θ = (j) when $Y_j = 1$

r = freight rate expressed as Re/Km/lit.

The objective function is to minimise total cost T

$$T = r \sum_{i=1}^{M} \sum_{j=1}^{N} Y_j Z_{ij} Q_i D_{ij}$$

subject to the following constraints

(i) $$\sum_{i=1}^{M} \sum_{j=1}^{N} Y_j Z_{ij} Q_i = \sum_{i=1}^{M} Q_i$$

i.e., each demand centre must be allocated to some warehouse location.

(ii) $\sum_{i=1}^{N} Z_{ij} = 1 , \qquad i = 1, 2, \ldots\ldots M$

i.e., each demand centre to be allocated to only one warehouse,

(iii) $\sum_{j=1}^{N} Y_j \leqslant K$

i.e., there is an upper limit to the number of warehouses.

The heuristic algorithm to fulfil the above requirements is as follows :

STEP 1 : Initialisation : Form the matrix (a_{ij}) with the column vector A_j representing warehouse locations feasible and row vector representing the demand locations.

STEP 2 : Selection of First Location :

For each A_j, find $T_j = \sum_{i=1}^{M} a_{ij}$

Select A_j with minimum cost T_j as first location and call it A_1* Put $Y_j = 1$ and place j in ordered set θ.

STEP 3 : Selection of Next Location :

For each A_j, j excluding θ, find

$$S_j = \sum_{i=1}^{M} \min [0, (a_{ij} - a_{ij}^{*})]$$

This requires formation of Improvement Potential Matrix.

(a) If $S_j < 0$ for some j, find minimum S_j. For this value of j, put $Y_j = 1$ and place j in the next position of θ.

(b) If all $S_j \geqslant 0$, this indicates that additional warehouses will not reduce transportation cost. Therefore, the procedure may be terminated.

STEP 4 : Formation of Best Combination :

Remove the column vector with $j \varepsilon \theta$

Replace A^*_1 with a new column vector A^*_2 where

$$a^*_i = \min_{j \varepsilon \theta} (a_{ij}) \text{ with } i = 1, 2, \ldots\ldots M$$

This step indicates the result obtained with the combination of warehouses so far selected.

STEP 5 : Combination Improvement Check :

The effect of eliminating a particular chosen location from the solution is determined. If an insignificant location was selected earlier, it should be deleted and better location chosen.

STEP 6 : Check if $\sum_{i=1}^{N} Y_j = K$

if not, return to STEP 3

If yes, terminate the procedure.

Data Collection

Facility location decisions (considering only transportation cost) depend primarily on the location and capacity of supply sources, and location and need of demand centres. Table 1 gives the distances of all potential warehouses from the two supply sources at Bombay and Paharpur. A warehouse would receive supply from the closer of the two sources. For example, if it is decided to have one warehouse at Delhi, its supply source would be Paharpur. Therefore, heavy axle oil required at Delhi demand centre would be transported through a distance of 1023 Kms. If Delhi warehouse has to supply to subsidiary depot Kalka, a total distance of 1023 Kms + 303 Kms (track distance from Delhi to

Kalka) would have to be traversed. Knowing the distance between any pair of potential warehouse site and demand location, total distance matrix can be prepared (Table 2). As is obvious, all demand locations are potential warehouse sites.

Application of Shannon & Ignizio Model

STEP 1, Iteration 1 : Distance x Demand matrix formulation is shown in Table 3. It has 18 column vectors A_j with entries a_{ij}.

STEP 2, Iteration 1 : For each potential warehouse site j, T_j is determined

$$T_j = \sum_{I=1}^{1} a_{ij}$$

Warehouse site 18 is associated with minimum cost of transportation T_j. This would be selected as the first location if we can have only one warehouse.

$$\therefore\ Y_{18} = 1 \text{ and } \theta = (18)$$

STEP 3, Iteration 1 : To select the next promising location, an improvement potential matrix is formulated (Table 4). It is seen that $S_{12} = -3333$ is minimum. Hence, if two warehouses are to be located, site No. 12 would be the next choice, and it would cater to the needs of demand centres No. 12, 13, 14, 16 and 17.

$$\therefore\ Y_{12} = 1 \text{ and } \theta = (18, 12)$$

STEP 4, Iteration 1 : Column vectors 18 and 12 are removed since they have already entered the solution. A^*_1 is replaced by a new column vector A^*_2 (Table 4). Since the upper limit to the number of warehouses is eighteen, steps 3 and 4 are repeated.

STEP 3, Iteration 2 : To select the third promising location, S_j values are again determmined. They are shown in row S_{j2} in Table 4. Since $S_{11} = -45$ is minimum, site No. 11 would be chosen as the next location and it would serve the requirement of demand centre No. 6.

$$\therefore Y_{11} = 1 , \qquad \theta = (18, 12, 11).$$

STEP 4, Iteration 2 : The combined result of the selection of warehouse sites 18, 12 and 11 is indicated by column vector A^*_3.

STEP 5, : Combination Improvement Check shows that locations selected so far are most advantageous and no better location can be chosen. Continuing the above procedure, the following results are obtained:

Third Iteration : $\theta = (18, 12, 11, 2)$

Fourth Iteration $\theta = (18, 12, 11, 2, 10)$

Fifth Iteration : $\theta = (18, 12, 11, 2, 10, 3)$

Sixth Iteration : $\theta = (18, 12, 11, 2, 10, 3, 8)$

No further improvement is possible since all S_j values vanish. Additional warehouses will not reduce transportation cost. Therefore, main depots for heavy axle oil should be located at the above seven sites, and subsidiary depots at the remaining eleven sites.

Summary of Results

The results obtained by using Shannon and Ignizio model are summarised in Table 5. With increase in the number of warehouses, there is an increase in Trunk Hauling Cost (from supply sources to main depots); and there is reduction in Local Delivery Cost (from main depots to subsidiary depots). The total cost is minimised when the number of warehouses is seven.

	Present System	*Proposed Solution*
Number of main depots	3	7
Transportation cost factor (Kmxlit)	121.64×10^7	88.72×10^7
Annual Transportation Cost (Rs.)	2.433×10^6	1.774×10^6

Area Served	*Main Depot Site No.*	*Sub. Depot Site No.*	
	1	1, 2, 3, 4, 5, 6	See Table 5
	7	7, 8. 9, 10, 11, 18	
	12	12, 13, 14, 15, 16, 17	

The study may by continued further to take into account administrative cost which goes up with increase in the number of warehouses. Other factors affecting depot locatien (e.g., whether to locate a warehouse on main railway route or sub-route) can be taken into consideration in an objective manner by putting the decision parameters into the framework of 'Decision Matrix' technique [3]. □

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(1) Eilon, S. and Gandy, C. D. T. Watson 'Models for Determining Depot Location', *International Journal of Physical Distribution*, Vol. 1, No. 1, pp. 5-15.

(2) Shannon, Robert E. and Ignizio, James, P. 'A Heuristic Programming Algorithm for Warehouse Location', *AIIE Transactions*, Vol. 2, No. 4, p. 334.

(3) Mathur, R. K. 'A Physical Distribution Management Problem', *Unpublished M. Tech. Thesis submitted to Indian Institute of Technology*, Delhi, July 1977.

Table 1. : Distance Matrix from Source to Depot (All distances in track-km)

S. No	Depots (Potential Warehouse Sites)	Sources Bombay	Paharpur
1.	Delhi	1328	1023
2.	Ghaziabad	1408	999
3.	Kalka	1691	1267
4.	Saharanpur	1569	1080
5.	Bhatinda	1586	1539
6.	Ambala	1486	1162
7.	Lucknow	1420	560
8.	Kanpur	1397	600
9.	Tundla	1627	830
10.	Allahabad	1361	396
11.	Moradabad	1549	887
12.	Jodhpur	946	1624
13.	Bikaner	1722	1486
14.	Jasalmer	1247	1925
15.	Rewari	1342	1707
16.	Merta-Road	1050	1728
17.	Marwar	1050	1728
18.	Mughalsarai	2168	243

Table : 2 Total

(All distances

Potential Main Warehouse Sites

	1	2	3	4	5	6	7	8	9	10
1	1023	1019	1570	1261	1826	1360	1065	1035	1034	1021
2	1043	999	1590	1281	1846	1380	1045	1015	1014	1001
3	1326	1322	1267	1564	1811	1232	1368	1478	1337	1524
4	1204	1200	1751	1080	1823	1244	1079	1189	1215	1200
5	1310	1306	1539	1364	1539	1364	1352	1302	1321	1308
6	1221	1217	1337	1162	1741	1162	1161	1271	1732	1488
7	1528	1484	2075	1599	2331	1763	560	670	1131	817
8	1458	1414	2145	1669	2241	1833	630	600	1061	586
9	1227	1183	1774	1465	2030	2064	861	831	830	817
10	1648	1604	2195	1886	2451	2234	981	790	1251	396
11	1184	1180	1731	1173	1987	1237	886	996	1457	1143
12	1648	1644	2195	1886	2140	1985	1690	1560	1659	1616
13	1486	1482	2033	1724	1863	1823	1528	1498	1497	1484
14	1949	1945	2496	2187	2441	2286	1991	1961	1960	1947
15	1106	1102	1653	1344	1839	1443	1148	1118	1117	1104
16	1750	1746	2297	1988	2036	2087	1792	1762	1761	1788
17	1752	1748	2299	1990	2244	2085	1794	1764	1763	1790
18	1803	1759	2350	1840	2606	2081	878	945	1404	549

Demand Locations→

Distance Matrix

in Track kms.)

11	12	13	14	15	16	17	18	Demand for 3 month period
1048	1571	1949	2173	1425	1777	1779	1023	4500
1068	1591	1969	2193	1445	1797	1799	1003	20367
1351	1874	2252	2476	1728	2080	2082	1326	2000
1080	1752	2130	2354	1606	1958	1960	1080	15000
1335	1567	1810	2149	1642	1547	1755	1310	18000
1062	1769	2147	2371	1623	1975	1973	1162	4500
1213	2076	2454	2678	1930	1282	1284	561	20500
1283	1906	2384	2608	1860	2212	2214	588	45000
1514	1775	2153	2377	1629	1981	1973	819	10000
1634	2196	2574	2798	2050	2442	2444	396	5000
885	1732	2110	2334	1586	1938	1940	887	15000
1673	946	1763	1648	2050	1154	1154	1648	30000
1511	1223	1486	1825	1722	1223	1431	1486	20000
1977	1247	2064	1247	2351	1455	1455	1949	2000
1131	1654	1866	2256	1342	1860	1895	1106	5000
1775	1050	1659	1652	2152	1050	1258	1750	5000
1777	1050	1867	1652	2187	1258	1050	1750	3000
1531	2351	2729	2953	2205	2557	2557	243	80000

Table : 3 Distance ×

Potential Warehouses : j

Demand Location : i →	1	2	3	4	5	6	7	8	9
1	460	458	706	567	821	612	479	465	465
2	2120	2040	3244	2613	3665	2815	2132	2070	2070
3	265	264	253	313	362	246	274	296	267
4	1806	1800	2626	1620	2734	1866	1619	1784	1823
5	2358	2351	2770	2455	2770	2455	2434	2347	2378
6	549	548	602	523	783	523	523	572	779
7	3132	3042	4254	3165	4779	3614	1148	1373	2318
8	6561	6563	9653	7511	10121	8249	2835	2700	4775
9	1227	1183	1774	1465	2030	2064	861	831	830
10	824	802	1098	943	1226	1117	491	395	625
11	1776	1770	2597	1756	2981	1856	1330	1494	2186
12	4944	4932	6585	5658	6420	5955	5070	4680	4977
13	2972	2964	4066	3448	3726	3646	3056	2996	2996
14	390	389	539	437	488	577	398	392	392
15	553	551	827	672	920	722	574	559	556
16	875	873	1149	994	1018	1044	896	881	881
17	525	524	690	597	673	626	538	529	529
18	14424	14072	18800	14720	20848	16648	7624	7560	11232
$T^j = \sum a_{ij}$:	45761	45126	62191	49466	66465	54635	31682	31924	40079

Scale : 1 : 10^4

Demand Matrix (a_{ij})

10	11	12	13	14	15	16	17	18 (A^*_1)
459	472	707	877	978	641	799	999	460
2042	2178	3246	4017	4474	2948	3666	3666	2046
265	270	375	450	495	346	416	416	265
1800	1620	2628	3195	3531	2410	2937	2937	1620
2354	2403	2821	3156	3868	2956	2785	3159	2358
661	478	796	966	1067	730	889	889	523
1675	2487	4256	5031	5490	3957	2628	2628	1150
2637	5774	8577	11208	11736	8370	9954	9954	2646
817	1514	1775	2153	2377	1629	1981	1983	819
198	817	1098	1287	1399	1025	1221	1222	198
1715	1331	2598	3165	3501	2379	2907	2910	1331
4938	5019	2838	5289	4944	6150	3462	3462	4944
2968	3022	2446	2972	3650	3444	2446	2862	2972
389	395	249	413	249	470	291	291	390
552	566	827	933	1128	671	930	948	553
894	888	525	830	826	1076	525	629	875
537	533	315	560	496	656	337	315	525
4392	12248	18808	21832	23624	17640	20456	20456	1944
29293	42015	54894	67754	73833	57498	58670	59526	25619

Table : 4 Improvement

Potential Warehouses : →

Demand Locations : i→	1	2	3	4	5	6	7	8	9	10	11
1	0	-2	0	0	0	0	0	0	0	-1	0
2	0	-6	0	0	0	0	0	0	0	-4	0
3	0	-1	-12	0	0	-19	0	0	0	0	0
4	0	0	0	0	0	0	-1	0	0	0	0
5	0	-7	0	0	0	0	0	-11	0	-4	0
6	0	0	0	0	0	0	0	0	0	0	-45
7	0	0	0	0	0	0	-2	0	0	0	0
8	0	0	0	0	0	0	0	0	0	-9	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	-1	0	0	0	0
12	0	-12	0	0	0	0	0	-264	0	-6	0
13	0	-8	0	0	0	0	0	0	0	-2	0
14	0	-1	0	0	0	0	0	0	0	-1	0
15	0	-2	0	0	0	0	0	0	0	-1	0
16	0	-2	0	0	0	0	0	0	0	0	0
17	0	-1	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
S_{j1} =	0	-43	-12	0	0	-19	-4	-275	0	-31	-45
S_{j2} =	0	-18	-12	0	0	0	0	-11	0	-9	-45
S_{j3} =	0	-18	-12	0	0	0	0	-11	0	-15	-
S_{j4} =	0	—	-11	0	0	0	0	-4	0	-11	-

Potential Matrix

12	13	14	15	16	17	A*2	A*3	A*4
0	0	0	0	0	0	460	460	458
0	0	0	0	0	0	2046	2046	2040
0	0	0	0	0	0	265	265	264
0	0	0	0	0	0	1620	1620	1620
0	0	0	0	0	0	2358	2358	2351
0	0	0	0	0	0	523	478	478
0	0	0	0	0	0	1150	1150	1150
0	0	0	0	0	0	2646	2646	2646
0	0	0	0	0	0	819	819	819
0	0	0	0	0	0	198	198	198
0	0	0	0	0	0	1331	1331	1331
-2106	0	0	0	-1482	-1482	2838	2838	2838
-526	0	0	0	-526	-110	2446	2446	2446
-141	0	-141	0	-99	-99	249	249	249
0	0	0	0	0	0	0553	553	551
-350	-45	-49	0	-350	-246	525	525	525
-210	0	-29	0	-148	-210	315	315	315
0	0	0	0	0	0	1944	1944	1944
-3333	-45	-219	0	-2605	-2147			
-	0	0	0	0	0			
-	0	0	0	0	0			
-	0	0	0	0	0			

Table 5

No. of Warehouses	Warehouse Nos.	Area Served	Trunk Hauling Cost ($kmxlitx10^7$	Total Trunk Cost ($kmxlitx10^7$)	Local Delivery Cost ($kmxlitx10^7$)	Total Delivery Cost ($kmxlitx10^7$)	Total COST
1.	18	1-18	7.40	7.40	18.22	18.22	23.62
2.	18	1-11, 15, 18	5.95		9.96		
	12	12, 13, 14, 16, 17	5.67	11.62	0.70	10.66	22.28
3.	18	1-5, 7-11, 15, 18	5.84		9.55		
	12	12, 13, 14, 16, 17	5.69		0.70		
	11	6	0.40	11.93	0.08	10.33	22.26
4.	18	4, 7, 11, 18	4.63		5.08		
	12	12, 13, 14, 16, 17	5.67		0.70		
	11	6	0.40		0.08		
	2	1, 2, 3, 5, 15.	4.98	15.68	0.68	6.54	22.22
5.	18	4, 7, 10, 11, 18	3.26		2.95		
	12	12, 13, 14, 16, 17	5.67		0.70		
	11	6	0.40		0.08		
	2	1, 2, 3, 5, 15	4.98		0.68		
	10	8, 9,	2.18	16.49	1.30	5.71	22.20
6.	18	4, 7, 10, 11, 18	3.26		2.95		
	12	12, 13, 14, 16, 17	5.67		0.70		
	11	6	0.40		0.08		
	2	1, 2, 5, 15	4.78		0.59		
	10	8, 9,	2.18		1.30		
	3	3	0.25	16.54	0.03	5.65	22.19
7.	18	4, 7, 10, 11, 18.	3.26		2.95		
	12	12, 13, 14, 16, 17	5.67		0.70		
	11	6	0.40		0.08		
	2	1, 2. 15,	3.74		0.27		
	10	8, 9,	2.18		1.30		
	3	3	0.25		0.03		
	8	5	1.08	16.58	0.27	5.60	22.18

GERT and Related Topics : Basic Concepts (I)†

M. Krishnamoorthy* & J.P. Saksena**

Introduction

GERT, an acronym for Graphical Evaluation and Review Technique, is a procedure for the study of stochastic networks composed of *Exclusive-Or, Inclusive-Or*, and *and* nodes (vertices) and multi-parameter branches (transmittances or edges). In GERT, branches of the network are described by two or more parameters: (a) a probability that the branch is traversed, and (b) the time (or other attribute) to traverse the branch if it is taken. A transformation is developed that combines these two parameters into a single parameter. For *Exclusive-Or* nodes, a method is derived for the evaluation of networks in terms of the probability of realising an output node, and the moment generating function of the time to realise the output node. The total concept of stochastic networks, the transformation, and the evaluation method is labelled as GERT. These basic concepts are dealt in this paper.

For *Exclusive-Or* logic nodes, even if the times associated with the branches are random variables, GERT still yields an exact solution. Computer programmes have been written to obtain such solutions. For the other logic nodes, conceptual and computational problems still exist. These problems are discussed in this paper and approaches and approximations are also outlined. As a part of the evaluation and review process associated with stochastic networks, a sensitivity analysis of stochastic networks is included with GERT.

In performing the research to derive GERT, it was found that many systems could be described in terms of stochastic networks and that many problems could be solved using GERT.

The technique has found useful applications in a number of areas like

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†The second and the concluding part, 'GERT and Related Topics : Applications' will appear in April-June 1980 (Vol. XXI, No. 1) issue of PRODUCTIVITY.

simulation, queues, complex production systems, reliability and Markov processes. These applications will be dealt with in Part II. Simulation applications are due to McDonald, Moder, Saigal and Pritsker. The queuing applications are by Shah, Branson, Townsend, Maggard and Hogg. Their efforts are on finite queuing problems, item differentiation capabilities and GERT-QR. The next application is on complex production systems, where contributions of Eisner, Pritsker, Chilcott, Phillips, Morse and Taylor are of great significance. Beyer, Whitehouse and Poiage discuss reliability applications. The works of Hornbarker and Howard are major contributions from the point of view of Markov and semi-Markov processes.

BASIC CONCEPTS

Signal Flow Graphs

In this section, the basic concepts of Signal Flow Graphs (SFGs) are introduced. They are analytical tools, often used in the modelling and analysis of linear systems. Although their use originated in the analysis of electrical networks, increased interest in SFG derives from the importance of the analysis and synthesis of linear systems occurring in many fields of science and engineering. It is a known fact that irrespective of their content, many systems can be modelled as a set of linear equations, to which the methodology of SFG theory is directly applicable. Such diverse problems as stochastic systems of the Markovian or semi-Markovian types, as well as dynamic systems giving rise to linear differential equations can be analysed through SFGs.

The generic element of SFGs is shown in Fig. 1(a). It consists of a directed arc (i.e., an arrow) connecting two nodes, the 'origin' x_1 and the 'terminal' x_2. The arc is said to be of transmittance w_{12} meaning the value of the node x_1 is multiplied by w_{12} and it is transmitted in the arc such that the variable represented by x_2 is defined by $x_2 = x_1 w_{12}$.

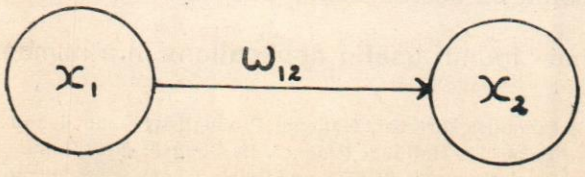

Fig. 1 (a)

In general, more than one arc may leave any node and more than one arc may terminate at any node. In the former case, the value of the node is multiplied by the transmittance of each arc emanating from it, while in the latter case, the value of the node is equal to the sum of the inputs into it. These two properties define the equivalent transmittance in the case of parallel paths.

$$x_2 = x_1(w_{12}+w'_{12}+w''_{12})$$

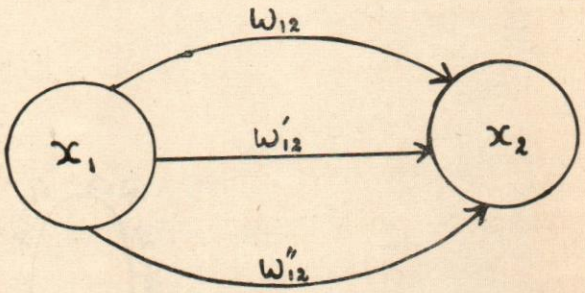

Fig. 1 (b) : Parallel Paths

On the other hand, it is obvious that for iwo arcs in series, the value of x_3 is given by

$$x_3 = x_2w_3 = x_1w_{12}w_{23}.$$

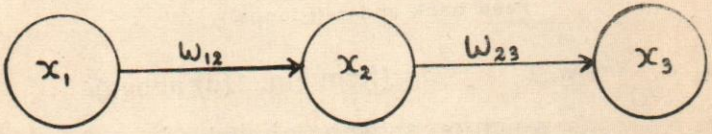

Fig. 1 (c) : Branches in Series

Thus, the transmittance of the arcs in series multiply and while that of arcs in parallel add.

Sometimes we are concerned with feedback and self loops as shown below Fig. 1(d) and the question that arises is : 'What is the value of the variable x_4 ? From the graphs, we have

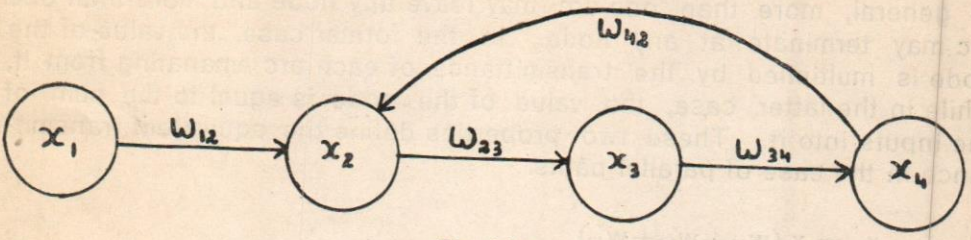

Fig. 1 (d)

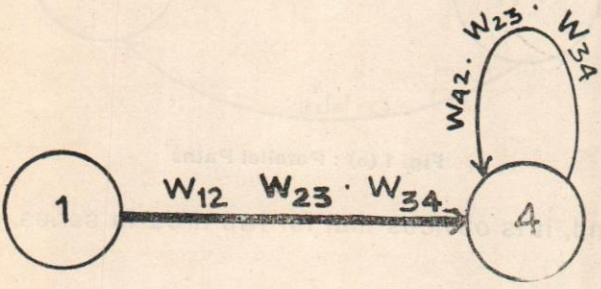

Fig. 1 (e)

Feed back and self loops

$x_2 = (x_1 w_{12} + x_4 w_{42})$ (from Fig. 1(d) above)

$x_3 = x_2 w_{23}$, which on substitution yields

$x_3 = (x_1 w_{12} w_{23} + x_4 w_{42} w_{23})$

$x_4 = (x_3 w_{34})$

$= x_1 w_{12} w_{23} w_{34} + x_4 w_{42} w_{23} w_{34})$ (also corresponds to Fig 1(e)).

Hence $x_4 = \dfrac{w_{12} w_{23} w_{34} x_1}{(1 - w_{42} w_{23} w_{34})}$

The feed back loop in Fig. 1(d) is first reduced to a self loop as in Fig. 1(e), having a loop transmittance l. The self loop is then further reduced to an arc in series as in Fig. 1(f) shown below :

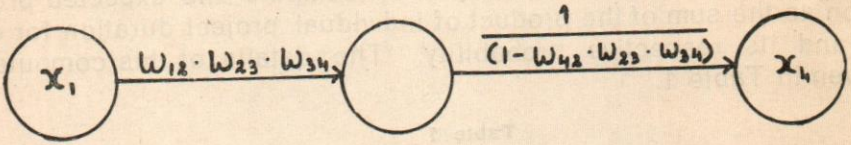

Fig. 1 (f)

Applying the same formula used earlier for two arcs in series, the path transmittance from node (1) to node (4) is seen as in Fig. 1(g) :

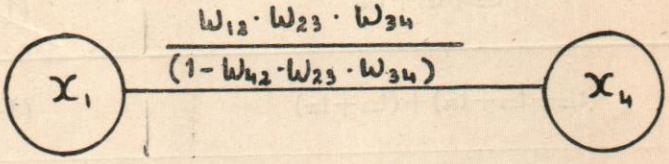

Fig. 1 (g)

Thus, any signal flow graph having a combination of series, parallel and feedback arc can be systematically reduced either algebraically or the equivalent network configuration to obtain transmittance from any one node to another.

A Trivial Example

Consider a network having a single feed back loop as in Fig. 2, with deterministic duration t_{ij} for each activity i,j.

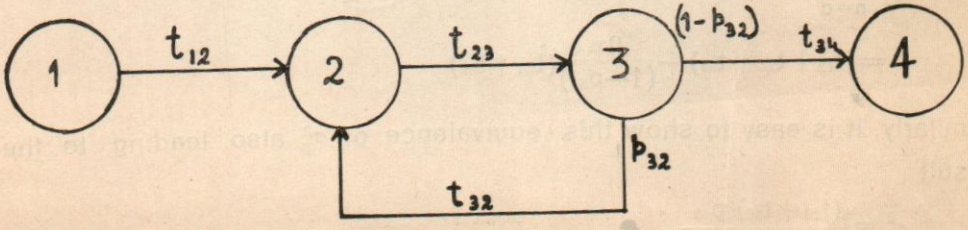

Fig. 2

It may be noted that activities (3,4) and (3,2) branching from node (3) have a probabilistic branching. Using fundamental principles, we may analyse the project duration and its probability of occurrence for each cycle through the feed back loop and compute the expected project duration as the sum of the product of individual project duration for each cycle and its respective probability. The details of this computation are given in Table 1.

Table 1

Cycle	Project Duration	Probability
0	$t_{12}+t_{23}+t_{34}$	$(1-p_{32})$
1	$(t_{12}+t_{23}+t_{34})+(t_{23}+t_{32})$	$(1-p_{32})\ p_{32}$
2	$(t_{12}+t_{23}+t_{34})+2(t_{23}+t_{32})$	$(1-p_{32})\ p_{32}^2$
⋮	⋮	⋮
n	$(t_{12}+t_{23}+t_{34})+n(t_{23}+t_{32})$	$(1-p_{32})\ p_{32}^n$

$$\mu_g=\sum_{n=o}^{\infty}\{(t_{12}+t_{23}+t_{34})+n(t_{23}+t_{32})\}\ (1-p_{32})p_{32}^n$$

$$=(t_{12}+t_{23}+t_{34})+\frac{p_{32}}{(1-p_{32})}(t_{23}+t_{32})$$

Similarly, it is easy to show this equivalence of σ_g^2 also leading to the result

$$\sigma_g^2=\frac{(t_{23}+t_{32})^2p_{32}}{(1-p_{32})^2}$$

The values of (μ_g) and (σ_g^2) arrived at for the trivial example using fundamental principles of feed back cycling may also be verified by the application of signal flow graph technique as shown in Fig. 3.

The Trivial Example (SFG Solution)

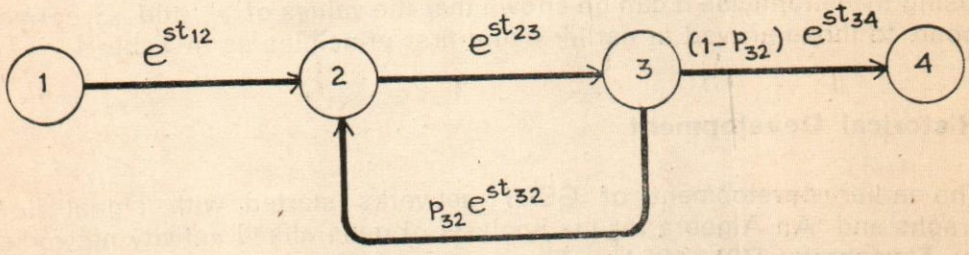

Fig. 3

The stochastic feedback network given in Fig. (3) has *deterministic* activity durations for all activities with one probabilistic branching in node (3). The flow graph reduction procedure introduced in the previous section is equivalent to seeking a solution to a set of simultaneous equations. To enable this algebraic manipulation, it is first necessary to obtain the moment generating function (m.g.f.) M_{ij} of activity duration t_{ij} and obtain the arc transmittance $w_{ij}=(P_{ij}.M_{ij})$ where p_{ij} is the probability of realisation of activity (i,j). The resultant signal flow graph for the trivial example of Fig. 2, is shown in Fig. 3. Let w_g be the graph transmittance from the origin (1) to the terminal (4). Accordingly

$$x_2 = x_1\, e^{st_{12}} + x_3\, p_{32}\, e^{st_{32}}$$

$$x_3 = \frac{x_1\, e^{s(t_{12}+t_{23})}}{1-p_{32}\ e^{s(t_{32}+t_{23})}}$$

and $$w_g = \frac{x_4}{x_1} = \frac{(1-p_{32})\, e^{s(t_{12}+t_{23}+t_{34})}}{1-p_{32}\ e^{s(t_{32}+t_{23})}}$$

Since by definition, $w_g=(p_gM_g)$ i.e., the product of the probability of occurrence of the project (g) (which is equal to unity) and the m.g.f. of the project duration t_g, it can be shown that the expected project

$$\text{duration } \mu_g = \left.\frac{dw_g}{ds}\right|_{s=0}$$

$$\text{and, the project variance } \sigma_g^2 = \left\{ \left.\frac{d^2 w_g}{ds^2}\right|_{s=0} - \mu_g^2 \right\}$$

Using these formulae it can be shown that the values of μ_g and σ_g^2 correspond to those arrived at earlier using first principles as in Table 1.

Historical Development

The earlier development of GERT networks started with signal flow graphs and 'An Algebra for the analysis of generalised activity networks' by Elmaghraby [(2), 1964]. This paper generalises the approach of activity networks, exemplified by PERT and CPM, to networks in which activities and durations occur probabilistically and where logical relationships of a more complicated nature exist. For example, from a specific event some activities are undertaken with certainty while others probabilistically. It presents an algebra of analysis taking the decision rules or logical structures of the systems as given. The approach is applicable to the analysis of practical situations such as contract bidding, flow in shops, etc.

This work was further extended by the same author in 'On generalised activity networks'. The paper presents the algebra used for graph reduction in analysis of generalised activity networks and the specific case of networks with *Exclusive-Or* nodes. The concepts of generalised activity networks are extended to the case of conditional parallel progress with the deterministic and probablistic time estimates.

The work of Elmaghraby was further extended by Pritsker, who in a series of papers, developed the idea to a large extent and is responsible in placing the theory on a firm footing. His earlier paper was a Rand Memorandum entitled 'GERT Graphical Evaluation and Review Technique' [(10), 1966]. This was further developed in two papers—Part I, Fundamentals and Part II—Probabilistic and Industrial Engineering Applications, both written in the Journal of Industrial Engineering, [(11,12), 1966].

Generalised Formulation

This development was further extended by Krishnamoorthy through signal flow graph approach. He has derived generalised formulae for w_g, μ_g and σ_g^2 in this paper. Let the network have paths $k=(1,2,\ldots,K)$ each path having A_k activities in sequence. Let h be a set of activities forming a loop $(h=1,2,\ldots,H)$. For the r^{th} order of combination of non touching loops for the path k, let l_{rk} represent the set of r numbers of elementary loops h and let there be L_{rk} such combinations for the r^{th} order $(r=1,2,\ldots R_k)$. At the graph level let l_{rg}, L_{rg} and R_g represent the corresponding limits. This graph transmittance w_g is built up from activity transmittances w_{ij} in the following manner :

$$w_g = \frac{\sum_{k=1}^{K} w_k \left[1+\sum_{r=1}^{R_k} (-1)^r \left(\sum_{l_{rk}\varepsilon L_{rk}} w_{l_{rk}} \right) \right]}{1+\sum_{r=1}^{R_g} (-1)^r \left(\sum_{l_{rg}\varepsilon L_{rg}} w_{l_{rg}} \right)}$$

where

$$w_k = \prod_{i,j\varepsilon A_k} w_{ij}$$

$$w_{l_{ry}} = \prod_{h\varepsilon l_{ry}} \left(\prod_{i,j\varepsilon h} w_{ij} \right) = \prod_{h\varepsilon l_{ry}} w_h \quad , \quad y=g, k$$

$$w_{ij} = p_{ij} M_{ij} = p_{ij} E\,[\exp.\,(st_{ij})].$$

In the equation given above, p_{ij} is the probability of the activity (i,j) and M_{ij} is the moment generating function of its activity duration t_{ij}.

The expected value μ_g and variance σ_g^2 at the project level are calculated by using the two formulae (given below) derived from the first principles, differentiating the numerator (u) and the denominator (v) of w_g and putting $s=0$ as required.

$$\mu_g = \left(\frac{u_o'}{u_o}\right) - \left(\frac{v_o'}{v_o}\right)$$

$$\sigma_g^2 = \left(\frac{u_o''}{u_o}\right) - \left(\frac{v_o''}{v_o}\right) - \left(\frac{u_o'}{u_o}\right)^2 + \left(\frac{v_o'}{v_o}\right)^2$$

Let A_x represent any one of the sets of activities in series as in A_k or in a loop as in h.

Then

$$w_x = \prod_{i,j\varepsilon A_x} w_{ij} = \prod_{i,j\varepsilon A_x} p_{ij} \prod_{i,j\varepsilon A_x} M_{ij} = P_x \prod_{i,j\varepsilon A_x} M_{ij},$$

$$w_x' = P_x \sum_{y\varepsilon A_x} \prod_{(i,j)\varepsilon[A_x - y]} M_{ij} \cdot M_y'$$

$$w_{xo}' = P_x \sum_{y\varepsilon A_x} E(t_y) = P_x \mu_x.$$

Finally

$$\mu_g = \frac{\sum_{k=1}^{K} P_k \left\{ \mu_k + \sum_{r=1}^{R_k} (-1)^r \sum_{l_{rk}\varepsilon L_{rk}} P_{l_{rk}} \left(\mu_{l_{rk}} + \mu_k \right) \right\}}{\sum_{k=1}^{K} P_k \left(1 + \sum_{r=1}^{R_k} (-1)^r \sum_{l_{rk}\varepsilon L_{rk}} P_{l_{rk}} \right)}$$

$$- \frac{\sum_{r=1}^{R_g} (-1)^r \sum_{l_{rg}\varepsilon L_{rg}} P_{l_{rg}} \mu_{l_{rg}}}{1 + \sum_{r=1}^{R_g} (-1)^r \sum_{l_{rg}\varepsilon L_{rg}} P_{l_{rg}}}$$

where,

$$P_{l_{ry}} = \prod_{h\varepsilon l_{ry}} P_h = \prod_{h\varepsilon l_{ry}} \prod_{i,j\varepsilon h} p_{ij}, \quad y = k,g$$

and

$$\mu_{l_{ry}} = \sum_{h\varepsilon l_{ry}} \mu_h = \sum_{h\varepsilon l_{ry}} \sum_{i,j\varepsilon h} \mu_{ij}, \quad y = k,g$$

Similarly, generalised formula for σ_g^2 can also be presented involving σ_k^2 and $\sigma_{I_{ry}}^2$.

We may now verify the applicability of the generalised formula for the case of a single path i.e., ($K=k=1$, $L_{rk}=I_{rk}=\Phi$), as in trivial example Fig. 2 above, having A_l activities in series $A_l=[(1,2), (2,3), (3,4)]$ and a single loop h, i.e., ($L_{rg}=I_{rg}=h$ and $R_g=1$), $h=\{(2,3), (3,4)\}$.

Accordingly, the generalised formula for μ_g' is reduced to

$$\mu_g=\mu_1+\mu_h\left(\frac{P_h}{1-P_h}\right)$$

where $\mu_1=\sum_{i,j\varepsilon A_l} E(t_{ij})$

$$\mu_h=\sum_{i,j\varepsilon h} E(t_{ij})$$

and $P_h=\prod_{i,j\varepsilon h} p_{ij}$

In the specific example under consideration, further substitution of values for A_l and h yield

$$\mu_g=\left[(t_{12}+t_{23}+t_{34})+\frac{p_{32}}{(1-p_{32})}(t_{23}+t_{32})\right]$$

These values correspond to the results obtained from the first principle (page 414). A similar exercise may be carried out for calculating the project variance σ_g^2.

Project Variance Analysis

A description of general formula for w_g, μ_g and σ_g^2 and their application to the trivial case of a single path having a single feedback loop has been given in the last section.

Two special cases of this formula by Krishnamoorthy and Rao, [(8), 1972] are of interest here. In the first case, the activities are all deterministic. In the other, they are probabilistic (discrete or continuous) with the restriction that the expected value is equal to the variance. The difference

between the project variance for these two cases has been shown equal to the expected value of project duration.

For any network containing the mixture of these two extreme cases, the difference in variance at the project level will be less than its expected value. This measure, therefore, provides boundary conditions for project variances. Similar quantitative measures between the variances can be readily obtained from the general formula for any explicit relationship between standard deviation and expected value at the activity level. The utility of the general formula lies in providing a basis for a detailed sensitivity analysis of GERT networks Section two of the paper[(8), 1972] uses a conditional probability approach to obtain these measures under certain restrictive assumptions. The last section provides an equivalence between the two for a trivial case under the assumption of geometric cycling.

Sensitivity Analysis

The paper by Hill [(4), 1967], develops a systematic method for obtaining the sensitivity information about a system and shows how to utilise this information to obtain system performance. The concept of a closed graph is developed and the topology equation, which describes the relationship of all the variables in a system, is derived.

The next paper is by Raju [(14), 1971] entitled : 'Sensitivity Analysis of GERT Networks'. Sensitivity is an important concept in network evaluation, review and improvement (design). A sensitivity analysis details the changes in the performance measure as a function of changes in parameters (components) of a network. Equations are obtained to calculate the changes in the performance measure due to changes in its several parameters. These equations are used in improving the system performance and in calculating the range of variations of the performance measure.

System improvements in GERT networks is achieved by increasing the equivalent probability and by decreasing the equivalent time and cost. The range is used in finding the effect of parameter variations on the confidence limits of the equivalent time and cost.

This work was further extended by Krishnamoorthy, 'Project Variance

Analysis of GERT Networks', [(9), 1972]. The paper presents in three parts, variance analysis of GERT networks. The first part presents the theoretical framework which makes uses of w—functions to compute performance measures such as mean value and variance at the project level on the basis of similar parameters at the activity level. The system of equations provide a general approach to any *'Exclusive—Or'* GERT network configuration. In particular, it is shown that the project variance can be separated into two distinct components, one involving the activity mean and the other involving the activity variance.

This separation is maintained in the next part, which presents a generalised approach to sensitivity studies of different performance measures at the project level or at the sub-project level. This concept is illustrated with the help of a small example, which provides a basis for decomposition of large GERT networks for purposes of sensitivity studies.

Learning Effects

Another paper by Krishnamoorthy [(8), 1972] deals with the effect of learning in a given *Exclusive—Or* type of GERT network. For example, consider the trivial case of a single path having only one feed back cycle referred to earlier. Assume that every time feed back occurs from node (3) to node (2), the effect of learning is to reduce the probability p_{32} by a fraction α, $(0<\alpha<1)$ such that, at the n^{th} cycle, the probability of realisation of activity (3,2) is $p_{32}\,\alpha^n$.=Using Table 2, the expected project duration is computed for the network in Fig 4.

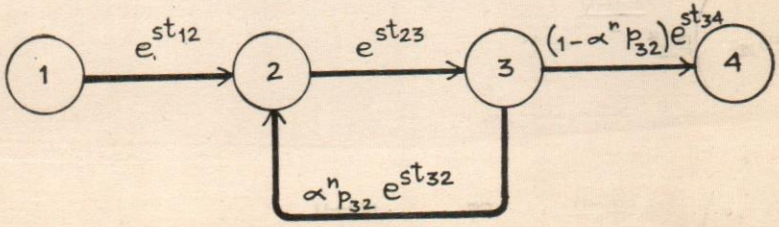

Fig. 4

Table : 2

Cycle	Project duration	Probability
0	$(t_{12}+t_{23}+t_{34})$	$(1-P_{32})$
1	$(t_{12}+t_{23}+t_{34})+(t_{23}+t_{32})$	$P_{32}(1-\alpha P_{32})$
2	$(t_{12}+t_{23}+t_{34})+2(t_{23}+t_{32})$	$P_{32}.(\alpha P_{32})(1-\alpha^2 P_{32})$
⋮	⋮	⋮
n	$(t_{12}+t_{23}+t_{34})+n(t_{23}+t_{32})$	$P^n{}_{32}(\alpha.\alpha^2\ldots\alpha^{n-1})(1-\alpha^n P_{32})$

$$\therefore \mu_{ge} = \sum_{n=0}^{\infty} \left\{(t_{12}+t_{23}+t_{34})+n(t_{23}+t_{32})\right\}(1-p_{32}\alpha^n)p_{32}^n\ \alpha^{\frac{n(n-1)}{2}}$$

where μ_{ge} is the expected project duration with learning.

A solution to this summation problem could be arrived at with the help of the following two basic results :

$$\sum_{n=0}^{\infty}\left(1-p_{32}\alpha^n\right)p_{32}^n\alpha^{\frac{n(n-1)}{2}}=1$$

and

$$\sum_{n=0}^{\infty} n\left(1-p_{32}\alpha^n\right)p_{32}^n\alpha^{\frac{n(n-1)}{2}} = \sum_{n=1}^{\infty} p_{32}^n\ \alpha^{\frac{n(n-1)}{2}}$$

Hence

$$\mu_{ge} = (t_{12} + t_{23} + t_{34}) + (t_{23} + t_{32}) \sum_{n=0}^{\infty} p_{32}^{n} \alpha^{\frac{n(n-1)}{2}}$$

However, the project duration μ_g where learning effect is neglected has the form

$$\mu_g = (t_{12} + t_{23} + t_{34}) + (t_{23} + t_{32}) \sum_{n=1}^{\infty} p_{32}^{n}$$

It is evident from the above that the reduction in project duration due to learning is

$$\mu_g - \mu_{ge} = (t_{32} + t_{23}) \sum_{n=1}^{\infty} p_{32}^{n} \left(1 - \alpha^{\frac{n(n-1)}{2}} \right)$$

Since α is a positive fraction (i.e., $0 < \alpha < 1$), $\alpha^{\frac{n(n-1)}{2}}$ is also a positive fraction and as such it is seen from the above that $\mu_g > \mu_{ge}$ and the effect of learning could be measured in terms of a quantifiable reduction in project duration. This simple formula could be subjected to variations in line with relaxation of assumptions with regard to learning at the activity level. □

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Book Reviews

Introduction to Work Study

International Labour Office; Geneva: 1979; Third (Revised) Edition, pp 442; 25 Swiss Francs

Reviewed by Dr. Krish Pennathur*

When the First Edition of 'Introduction to Work Study' was published in 1957, it was primarily intended as a text book for participants attending courses on Work Study. C. R. Wynne Roberts, who wrote this in collaboration with E. J. Riches, succeeded admirably in achieving this aim. A second revised edition was prepared by R. L. Mitchell in 1969. It contained no radical changes from the First edition, except for some additional and revised material on a few topics.

This third revised edition is truly a revised edition meeting the set goals of bringing the contents up to date, changing from an introductory nature to one of usefulness to practitioners and teachers as well and enriching it with numerous examples of the application of the techniques and approaches. Chapter 6, on Working Conditions and Working Environments, has been completely rewritten with a significantly pragmatic treatment of the influence of Ergonomic factors on the practice of Work Study. While the previous editions devoted only one chapter to 'Other Techniques of Work Measurement', this edition has, in addition, two other chapters, one dealing with Work Sampling and the other with Predetermined Time Standards. The previous chapter on Organisation of a Work Study Department has been wisely omitted. Instead, Part Four on New Forms of Work Organisation has been freshly added. This has enhanced the value of the book. While there were 97 figures in the Second edition, this one contains 141—abundant by any standard. The number of tables has been increased from 14 to 27.

The application of Work Study techniques differ from country to country. Even the terminologies are sometimes different. To write a book to cater for a world-wide Work Study population is indeed an arduous task. The simplicity with which complex problems, modern advances and current experiences have been portrayed is, therefore, highly commendable.

The Third Edition comprises five parts. The first on Productivity and Standard of Living has six chapters Part Two is on Method Study with chapters on

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Introduction and Selection of Job, Record, Examine and Develop, Flow and Handling of Materials, Movement of Workers in the Work Area, Methods and Movement at the Work Place and, lastly, Define, Install and Maintain. Part Three gives an elaborate and comprehensive treatment of Work Measurement, with 11 chapters on the subject. Part Four is a new one on 'From Analysis to Synthesis : New Forms of Work Organisation'. Part Five contains Appendices.

Critical Examination is the crux of Method Study. No book on Work Study published abroad has done justice to this vital subject. This book is no exception. Slightly over six pages have been allocated to this topic. The Indian book, Modern Method Study, contains 166 pages on Critical Examination alone, copiously illustrated by case examples from different sphers of economic activities. It is to be hoped that the next edition by the ILO would give Critical Examination the importance it deserves.

The book has strengthened the chapter on Work Measurement. But, this branch of Work Study is fast losing its prime role in many countries. Instead of enlarging the subject of Work Measurement, more emphasis could probably have been laid on Method Study. 'Recording of Facts' is a necessary prelude to Critical Examination. The book confines itself to conventional recording techniques, charting processes and diagrams. The Institute of Management Services, UK, has developed several other aspects of Recording Facts which facilitates Critical Examination against a broader perspective. This book could have incorporated some of these concepts. The problem has apparently been not one of what to include, but what to exclude or abridge. In this exercise of judgement, the book appears to suffer from a slight imbalance. It is nevertheless conceded that It is difficult for an author to cater to a wide variety of tastes and requirements.

In spite of the above comments, this book should prove to be an invaluable aid to students, practitioners, teachers and managers. If only the ILO could devise some means of bringing the price of the book down, it would be within the range of affordability of a vast multitude of Work Study students. No doubt, costs have gone up to prohibitive scales in the publishing field. Probably a subsidy, particularly for sales effected in developing countries, may be one answer This may not be all that easy, considering the strained financial resources of the ILO. Still, ways and means of bringing out a cheaper edition must be found if productivity disciplines are to be widely propagated and promoted. □

Management of Materials

B. K. Roy Chowdhury

Sultan Chand & Sons, New Delhi, pp. 123, Rs. 30.00

Reviewed by R. C. Monga*

The social responsibilities of business have been debated for quite some time in our country, but the form and content of such responsibilities is still illusive. However, one thing is clear : that organisations cannot live in isolation of external influences and each organisation, as an effective organ of the society, must draw its own plans, policies and actions to fulfil social obligations. Materials management is one area where the organisational and national interests are inherently compatible. Effective management of materials encompassing all activities like planning, purchasing, and storage of materials can appreciably improve the performance of the unit and also contribute to the national economy by promoting substitution of scrace and imported materials, waste reduction measures, and use of modern inventory control techniques for releasing scrace capital for more productive use. Any literature, especially authored by a practitioner based on his long experience, is a welcome addition from the point of view of providing practical guidelines to the managers for effectively tackling complex problems encountered in a developing economy.

The major portion of the present book, based on a series of articles by the author, published in leading journals and financial dailies of the country, is devoted to an analysis of essential features of one aspect of Materials Management, i. e., purchasing, not-with-standing the title 'Materials Management' on the cover of the book.

The book starts off promisingly by discussing the problems faced by materials management personnel in procuring quality materials at reasonable prices, storing and distributing the same to the user departments but the treatment of the organisation for Materials Management should have been more pointed and comprehensive to explain the present day concept and philosophy of materials management. Some of the important issues like centralisation *vs.* decentralisation, relationship between production control and materials management merit detailed discussion rather than a mere mention in the book.

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At present, adequate attention is not being paid to the activities of source selection and development and finding out availability of raw materials, spare parts and components in national and international markets. The author has rightly focussed the attention of the reader on important factors impeding the effectiveness and productivity of a purchase department. The chapter on Availability Research on Materials deals with organising research, development of information, and evaluation of the source of supply and data collection/ analysis. The chapter on Research on Purchasing underlines the need for carrying out research and helps in understanding the conceptual framework and chalking out a strategy for implementation. The factors aiding the selection of a right supplier have been highlighted in the chapter on Selection of Source of Supply. This discussion has only served the purpose of highlighting this important aspect of purchase with which most of the managers are familiar. However, it would have been of much more practical use, had the author presented an approach and *mechanism* for integrating all these factors.

The two chapters on Scrap Surplus and Obsolete Materials highlight an area which is of utmost importance to our country where conservation of scrace materials should be of primary concern to all of us. Each department can, and should, contribute towards reducing scrap, surplus and obsolete materials by proper planning, purchasing and utilisation of materials. The role of different departments and reasons for scrap, surplus and obsolete material has been analysed and useful suggestions put forward to exercise control. Creation of an environment whereby each individual considers it a part of his normal duties will bring optimum results. The author goes on to suggest that a separate 'Waste Management' department should be created to deal with matters relating to improving material utilisation. He also discusses the probiems of quality and inspection in industry in general, and the role of purchase departments, stores, production and design departments for controlling the quality of purchased materials.

It would have been better, if the author had brought together subjects like organisation and training in separate chapters instead of treating them in piecemeal in different chapters as the two common reasons for non-performance are lack of proper organisation and suitable skills. The subjects like Value Engineering and Selective Approach to Buying have not found place in the book and, to that extent, discussion is incomplete. Nevertheless, the book presents some critical aspects of purchasing in a practical way and brings out useful and meaningful information for increasing the effectiveness of purchasing department. □

Performance Budgeting for Planned Development

K. S. Sastry

Radiant Publishers, New Delhi, 1979, Price Rs. 50.00

Reviewed by P. Chattopadhyay*

The book has as its theme the budgeting of public expenditure. The subject has now acquired some topicality in view of the appointment of the Misra Commission by the government for suggesting ways of controlling public expenditure and making it more productive and viable in the light of about thrity-five times growth in such expenditure during the period since 1951-52. Though there are other ways, performance budgeting is an important means of keeping public expenditure on the rail. Sastry focuses on the subject on a comprehensive scale, indicating that though the idea of performance budgeting has been accepted by the government more than a decade ago, and arising from the reports on the subject by the Administrative Reforms Commission and its Study Group, its absorption and integration into the working methods of budgeting have left a great deal to be desired.

In fact, performance budgets have generally figured only by way of ornaments to the receipt and expenditure budget of the government, thereby not only not realising the high potential of performance budgets but also making them wasteful. Meanwhile, for enriching the lip-service to budgeting as such, we have PPBS, output budgeting, programme budgeting, project budgeting and, last but not the least, zero-base budgeting, all vying with each other for getting into the shelf and forgotten in due course. This study by Sastry should give a jerk to all those concerned with both, making and operating the government budget, for giving performance budgets a fair trial.

One perhaps should not join issue with an author on his prefactory remarks. The author seems to suggest that PPBS, Programme Budgeting, Output Budgeting, etc., are attempts to graft the principles and techniques of management successfully tried in the private industrial sector into public administration. This is not perhaps a logical position to take, particularly

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budgeting; evaluation process; and lastly, implementational aspects. Each of these areas has been enriched by his insights gained from long years of experience in audit and accounts. By and large, he has been able to place the issues on a canvas with characteristic features of each. The urgency of the problem of control of public expenditure and the need for sensitising the performance budget mechanism have come out sharply. The Misra Commission would do well to take into view his observations on public expenditure control.

A detailed bibliography has enriched the value of the book which could have been further enhanced by inclusion of a list of the performance budgets for different Ministries and Departments of the government at the Centre and in the States. Several public sector enterprises have also introduced performance budgeting, a reference to which would have been highly appropriate. It commends itself for wide readership among managers, policy makers, teachers and researchers. □

R&D Productivity

Study Report of 1978, Second Edition

Hughes Aircraft Company, Culver City, California, pp. 183

Reviewed by V. Raghuraman*

Of late, there has been an increasing awareness to recognise Research & Development as an integral part of any productivity improvement; as only with R&D it is possible to sustain the standards of living expected by the world's increasing population The second edition of this report incorporates the conclusions and observations of the study teams sponsored by the Hughes Aircraft Company to identify the techniques for optimising productivity in the R&D environment spanning the period 1973-77 in two phases, the first phase covering 1973-74 the second from 1975-77.

The methodology adopted involving a galaxy of reputed organisations and consultants has been amply rewarded by the interesting findings of the survey.

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As technology is intertwined with productivity improvements, the role of the R&D is essentially complex, involving multifold variables such as personal factors, job-related factors and project related factors. It is also essential to fix the priorities in terms of short-term and long-term impacts, plan the time horizons, organise effective team work, coordinate and follow up the projects to ensure that the outputs are efficient as well as effective. Such a responsibility places the R&D in a vulnerable position. The efforts would be successful only with the involvement of the entire organisation and interfacing with other key activities such as marketing, contracts, finance, procurement, manufacturing, support and services.

The publication analyses all these factors in separate chapters and the whole material is presented in an easy-to-read type set with sub paras clearly marked and the salient points highlighted. There are twenty illustrations which are check lists for different parameters identified to meet the R&D objectives. The notable ones are the organisational effectiveness, review work sheet and the R&D managerial objectives chart. An attempt has also been made to estimate the R&D costs and time frames and broad-based incentive schemes suggested for effective performance.

A publication of this sort would have been complete, if sufficient cases collected during the course of the study were presented and the various factors impairing or aiding efforts of the R&D projects in the institutions which participated in the study analysed. One of the noteworthy features of this book is the elaborate bibliography and reference list suggested for further reading. This book is definitely a guide book for a broad spectrum of managers at all organisational levels and is not merely meant for R&D community alone. □

Meeting the Third World Challenge

Alasdair I. Macbean and V. N. Subramanyam (Second Edition)

Macmillan Press Ltd., London, 1978, pp. 272

Reviewed by P. L. Narayana*

The subject matter of the book—the challenges faced by the third world countries—is of perennial interest to the professional economists in the developed and under-developed countries. The international agencies like UN, World Bank and their associates have also taken keen interest in the subject as they have been striving to enhance the 'sacrifices and concessions' to be made by the industrialised nations so that the pace of economic growth is accelerated in less developed countries. A continuation of interest by the national governments and international agencies in the problems of third world countries arises because, in the ultimate analysis, it is the concern of everyone to make this world 'a place in which all mankind live without fear of hunger, crushing poverty and degradation'. This objective has remained an elusive goal despite large investments made by the national governments and international agencies during the last three decades. Professional economists have addressed themselves to the task of finding the causes for the existing state of affairs. The book under review is a signal addition to the existing literature which is not only expository in nature but also prescriptive in content.

The under-developed nations, soon after attaining political Independence, embarked on planned economic development with the objective of raising the living standards of their people so that they can catch up with the economically advanced countries. The political leadership has to bestow their immediate attention to this issue since economic distance between the rich and poor nations is no longer a secret, thanks to the 'explosive' development in communications. Thus to bridge or narrow the disparities in the living standards is the major challenge of the under-developed countries. In early stages of planning, it was assumed that by enhancing the levels of investment in industries and infrastructure, economic progress could be achieved quickly. The capital resources needed for investment are to be raised by 'squeezing the resources from the agricultural sector' and borrowings from abroad.

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Emphasis on rapid industrial growth has almost become a fetish in the development plans of the Third World countries. The industries chosen for development were either import-substitution type or heavy industries to produce raw materials and industrial machinery. Such an approach was favoured as it would lessen their dependence on advanced nations for these basic items. The over-emphasis on industrialisation to attain the goal of speedy economic growth is in fact adopted from the Russian experience since at that time a country's progress was often evaluated in terms of its success in transforming the agrarian economy into an industrialised one. India is no exception. In the earlier Five Year Plans of our country, rapid industrialisation, mostly import-substitution type, was considered the key to economic progress.

There is ample evidence to show that the investments made in the successive Five Year plans of many under-developed nations, including India, did lead to enhanced production in several sectors of the economy. Many products, consumer and industrial, are now produced in less-developed countries. Consequently, these countries have achieved laudable progress in industry, agriculture, transport and communications, etc. In fact, GNP growth rate noticed in selected Third World countries was even higher than the industrialised nations. Per capita income similarly showed a rising trend.

Now the question rightly to be asked is how far the progress achieved in different production sectors has helped in raising the living standards of the people. One is inclined to agree with the authors that the economic progress achieved so far has not helped in the betterment of the living standards of the 'least fortunate'. The per capita income differentials between the nations, or for that matter even among individuals, within the less developed nations tended to widen. Admittedly, the tools designed by economists to measure the economic distance are unsatisfactory. The problems in most Third World countries did not abate and a large proportion of the population are denied even the basic amenities of living. In the words of Robert MacNamara, 'what are we to say of a world in which hundreds of millions of people are not only poor in statistical terms, but are faced with day-to-day deprivations that degrade human dignity to levels which no statistics can adequately describe?' Widespread malnutrition in adult and child population, ill-health, inadequacy of medical facilities, poor housing, illiteracy, etc., are dominant features of most of the Third World countries. These need urgent solutions both in terms of political and social considerations. In this context, the review by the authors of the magnitude

of problems faced, past policies. the reasons for the failure is excellent and many economists tend to agree with them. Then if past attempts have failed to make a dent on the unholy trinity of rapid population growth, unemployment and inequalities of income and economic opportunity, what are the appropriate policies to tackle them ? The debate in India is also currently centered on these issues. The policy suggestions of the authors are worth noting.

Authors opined that rapid expansion of population is the chief reason for the low per capita income growth, unemployment and uneven income distribution; the last two are identified as the principal evils. These, obviously, have to be tackled without sacrificing the growth objective. It is now widely recognised by everyone in the developing world that in the absence of an effective check on population poverty cannot be alleviated. The authors seem to think that apart from disseminating the technology of family planning, changes in social customs are also necessary. Other suggestions made are multiplication of distributional points so that contraceptives are available widely at cheaper rates. At least in India, the performance in this regard is laudable. However, where the programme failed to make any dent is in the lower income groups, who consider an additional child as an extra source of income. All the efforts made in the past to limit the family size among these classes have made no impact mainly due to attitudinal barriers. Similarly, the suggestion of the authors in expanding the exports of manufactured goods, agricultural commodities and processed raw materials, though valid, have not succeeded in the past due to protective tariffs and quantitative restrictions imposed by the advanced nations. If these nations open their markets, by seizing the opportunity offered by the current Multilaterial Trade Negotiations in the GATT, trade can stimulate the economic activity in LDCs. Whether the advanced nations will actually seize the opportunity or not is a different question. Even if the policy gains currency, the fear expressed by the authors that the resultant benefits would accrue to the better-off Third World nations is still valid.

The authors think that certain changes are necessary in the aid programmes which would help to improve employment and equality in the Third World nations. The specific suggestion in this regard is giving of more aid to those sectors of the economy which use more labour-intensive methods, such as agriculture and its ancillary service industries, and labour-intensive manufactures and for small projects in rural areas where per-capita incomes are lower than average. The planners, in many less-developed nations, are

precisely thinking in these terms. But, as the authors have rightly recognised, 'few bilateral donors are likely to move very far in these directions' due to counter pressure on aid agencies if aid does not serve the commercial interests of the donor countries.

The present-day development economists advocate for labour-intensive techniques on the plea that such policies promote employment and reduction in poverty. Labour-intensive products are also considered more appropriate in low-income countries. Though authors warn us about the dilemmas in promoting such techniques, there is another dimension which has not received adequate attention in the literature on appropriate technology. Some of the empirical studies conducted in India and elsewhere show that labour-intensive methods of production are also material-intensive. Sugar manufacturing techniques being advocated in India is both labour-intensive and capital-saving in comparison to sugar mills. But due to a lower recovery, this technology requires more of sugarcane, which, besides escalating the manufacturing costs, necessitates bringing in more land under sugarcane crop. Such a choice is not easy in a country, such as India, where allocation of land to sugarcane is simply not feasible, as food crops such as cereals and pulses have a higher priority.

The book certainly provides valuable insights to the various problems faced by the developing countries. The tasks before the Third World countries are enormous. Because of the complex nature, the solutions are not easy particularly when political considerations dominate in investment decisions. It is also to be conceded that the science of economics cannot provide all answers. The limitations of economics are aptly described by Keynes thus : 'The Theory of Economics does not furnish a body of settled conclusions immediately applicable to policy. It is a method rather than a doctrine, an apparatus of the mind, a technique of thinking, which helps its possessor draw correct conclusions'. But the present day economists often trangress into realms, which are strictly outside their domain. □

Management Development : A Syndicate Approach

Dr. N. K. Kulkshetra

The H.C.M. State Institute of Public Administration, Jaipur 1979. pp. 38

Reviewed by Mani K. Madala*

This book is a dissertation of the author, based on his experiences as a Director of Management Programmes for Senior Executives in the government and the public sector undertakings in Rajasthan and his participation in the syndicate sessions in PATM programme, Department of Administrative Studies for overseas visiting Fellows, University of Manchester in 1977-78.

The author differentiates the general training—where the main aim is to bring about special learning behaviours—from 'management development', which has a special role to bring in actuating the thinking processes of managers to bring about innovation and creativity. He points out that the personality profile in terms of age, experience, etc., should be considered before one can bring about any development among the middle level managers and it is here that the syndicate method is of relevance. The mid-carreer executives, who have had some experience and have their minds saturated with well-tried methods and concepts, are generally dogmatic. To bring about any change in their stance, first their minds will have to be unfreezed. The syndicate method just caters to that need and allows them to speak their ideas, discuss their advantages and disadvantages and makes them improve upon those very ideas and methods in an open atmosphere. While discussing the features of the syndicate method, the author gives a functional and comprehensive definition, which is not very novel. "It is a self-managed, task-oriented, time-conscious and well-structured small group of persons representing, often, different shades of expertise/organisations functioning as a team to share their experiences and enrich themselves, deliberate and interact among themselves with a view to report back its deliberations to a plenary session."

However, the author's discussion about other training methods *vis-a-vis* the syndicate method is inadequate and does not compare the merits and

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demerits of various methods with the syndicate method. There is a lot of repetition while discussing the objectives, philosophy and uses, which could have been avoided. There are numerous statements which are vague and do not convey anything specific. "The Trainer has simply to provide necessary emotional support to make the syndicate discussions stimulating" (p. 16). The question is—What exactly is emotional support to the group? "Rather, it would be correct to say that the objectives give meaning and content to entire syndicate efforts and so act as horoscope of the syndicate exercise" (p. 18). One cannot understand what is meant by a horoscope of syndicate exercise. "The syndicate whose report is discussed defends it collectively like a lioness to her cubs" (p. 10). If one were to defend instinctively and without an open mind, where is the scope for creativity?

The chapter on evaluation of the syndicate method is one which deserves some commendation, for it attempts evaluation from various angles and presents mechanics as to how to go about it.

The whole work needs some pruning and improvement in style. The spelling and the grammatical mistakes outnumber the printing errors. However, the get up of the cover is attractive. □

Family Farming in a Developing Economy

R. K. Lahiri

Concept Publishing Co, pp 122, Rs. 32.00

Reviewed by Palat

Anyone involved in planning, even in a firm, will benefit by taking a quick look at the methodology used in this book for surveying the situation, recording it succinctly and drawing pragmatic conclusions; the book would also help those involved in market-research for consumer products and farm inputs in rural areas.

The book is written primarily for the rural specialist. The University of Kalyani, W. Bengal, to which Dr. Lahiri belongs, has pioneered some

excellent rural studies. This book describes the agricultural efficiency of family farms in Tripura and how to increase it. Economists have come a long way since "The Economics of Backward Areas" was introduced as a special paper in Economics at Oxford in the early fifties, based on unvoiced anthropological assumptions regarding the intrinsic inferiority of certain people which rendered them unsuitable for anything except agrarian pursuits. Dr. Lahiri's book lays this ghost once again.

The farmers' ability and readiness to make changes, according to the author, is a fact, the real reason for his backwardness being the continuing absence by the government to provide a meaningful infrastructure. His contention carries conviction, being based upon a pilot survey covering 15 months, and a field study covering 30 farms. It is a pity that the results have only been published recently, though, the study had ended by 1974. □

Fundamentals of Applied Evaluation

K. Puttaswamaiah

Oxford & IBH Publishing Company, New Delhi, 1979, Rs. 48.00

Reviewed by P. Chattopadhyay*

Formulation of projects and their appraisal and evaluation have assumed high significance in the context of planned economic development in the under-developed countries. In our country, in spite of the fact that we have about three decades of experience in design and formulation of plan schemes and also in their appraisal and evaluation, events have borne out that our planners as well as those in charge of execution have generally remained insensitive to the lessons of experience. Thus, same and similar mistakes have been repeated in one project or another and almost similar problems have repeatedly gotten schemes in the mud. What is more surprising is that the spate of Indian literature on the subject and ill-planned and ill-executed schemes are going on parallel lines. It is in the context of this lingering morass of under-development of plan schemes and their execution that this

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book will be found useful not only to see what plan schemes should have as their components but also how the plan schemes should be executed for better results at lower costs.

This study is in a series by the same author and he has enongh of exposure in both theory and practice of formulation and execution of plan schemes. The differences between reporting, appraisal and evaluation are discussed in the context of the argument presented in the first chapter on the need for evaluation and its scope, technique and method characteristics and criteria as also monitoring and review. The problems and perspectives of field investigation as also the statistical techniques of evaluation are analysed in the next three chapters which show the author's intimate acquaintance with the problem areas in such evaluation and the way one should go about in making evaluation effective. However, the statistical methods discussed by him are all preliminary though they have their relevance. He cautions that the appropriateness of the data to the problem in view should be underlined with reference to assessing whether such data and the analysis are good enough for drawing inferences. He disfavours facile generalisations and inadequate interpretation of statistical measures which can lead to a totally distorted view of both the plans and their executions. The current issues in cost-benefit analysis are summarised with reference to the state of the art and its uses for purposes of evaluation and appraisal of projects The author is right in suggesting that the introduction of cost-benefit analysis was more for justifying projects than for use as a tool for project planning. However, the scope of cost-benefit analysis is being extended rapidly covering areas as nebulous as social costs and as tangible as business profit. Though cost-benefit analysis owes its origin to project justification, it provides a primary scale of reference for purposes of control and evaluation. The centrifugal movements can be known and judged with reference to the CB ratio so that the deviations can be explained in proper terms and snags, if any, removed.

In the opinion of the author, where a strictly financial appriasal of a project gives an inadequate picture of its overall economic advantages or disadvantages to the community at large, it is necessary to employ cost-benefit analysis. He points out that the enumeration of costs and benefits to be measured is only the first stage of the analysis —quantifications of the inputs and outputs and their valuation offer real hard nuts to crack If one brings in considerations of shadow prices for such evaluation, one may get a picture far away from reality In this respect, different objectives sought to be satisfied by the decision-makers are to be taken into view. In general, however,

it is accepted that cost-benefit ratio should be less than one, benefits exceeding costs; the rate of return of the project should be acceptable from different points of view. Cost-benefit analysis has already reached a fairly high degree of sophistication and its application is also being extended to different problem areas, as the author has rightly pointed out. He has also taken into view such other techniques as PERT, CPM and line of balance, apart from input-output analysis, capital-output ratio, etc.

He makes a fervent plea for seriousness of approach to the context of evaluation and the practical problems encountered in making evaluation an effective means of control. The technique of writing evaluation reports has been discussed in some detail with reference to the author's own experience in the line. He has offered insights into the problem and his suggestions should be taken seriously by all those who are concerned with design and formulation of schemes and their execution. A detailed bibliography annexed to the volume has enhanced its value. □

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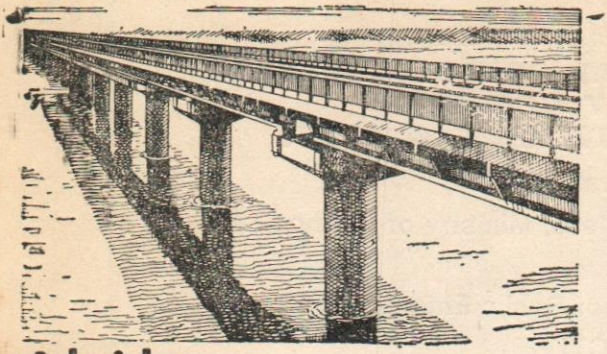

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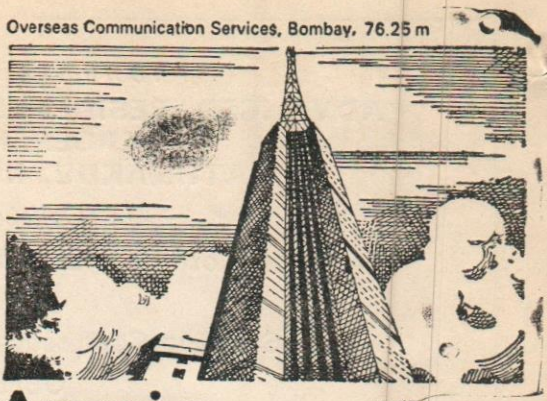

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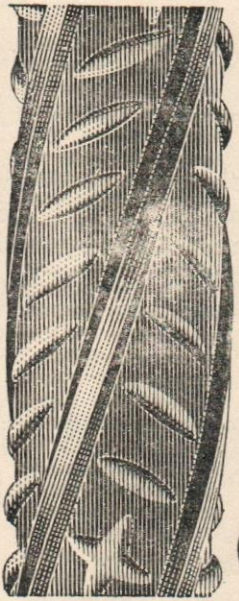

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Errata to

Labour Productivity and Output Growth in Indian Mining and Manufacturing Sectors (1951-76)

A supplement on Labour Productivity and Output Growth in Indian Mining and Manufacturing Sectors (1951-76) was published in PRODUCTIVITY (Vol. XX, No. 2), July-September 1979 issue. It is regretted that there were some errors in the computation of Tables 7, 8 and 9 (pp. S 30-35). Accordingly, related paras 1-5 (pp.S 7-8) also require some modification. Equations 1-4 (pp. S8-9) also were erroneously reported in the text although the empirical exercises relating to the model was carried out correctly. The following errata is, therefore, published in this issue. While sincerely regretting these errors, the authors wish to assure that the main findings of the supplement remain unaffected inspite of these corrections. *—Editor*

Paras 1–5 appearing on page S7–8 to be read as :

1. Against an annual average rate of growth of output of 11.70 percent, the total manufacturing sector records a rate of growth of 3.96 percent in employment and 3.97 percent in productivity during the 25-year period, 1951-75.

2. Similarly, against an average annual rate of growth of output of 9.84 percent, the total mining sector records a rate of growth of 1.65 percent in employment and 5.82 percent in productivity during the same period.

3. Thus, in the case of both the mining and manufacturing sectors, it is clear that the rate of growth of employment is considerably lower than that of output. If the resultant productivity increases (5.82 percent in the case of mining sector and 3.97 percent in the case of manufacturing sector) are mainly on account of increasing returns to employment, the situation would not have caused any concern. The available evi-

dences do not, however, corroborate this point of view[13]. This implies that at least a part of the increased productivity of labour is on account of capital intensification, a process through which labour is substituted by capital.

4. Among the mine groups, the highest rate of growth of output is recorded by 'other mines' (55.14 percent), followed by iron ore (38.01 percent), limestone (32.01 percent) and copper (17.44 percent). In the case of employment, however, limestone is on top (9.13 percent) followed by others (8.53 percent), copper (8.19 percent) and iron ore (6.75 percent). In 3 of the mine groups, employment actually declined during the period under review. Productivity increase is the highest in others, (15.30 percent), followed by iron ore (11.93 percent) and limestone (7.18 percent). The mine group-wise differences in the growth rates of output, employment and productivity are found to have a significant impact on the computed share of productivity increases in the total additional output during the period 1951-75, presented in Section III.

5. So far as the manufacturing sector is concerned, the rate of growth of output is the highest in machinery except electrical machinery (93.22 percent) followed by electrical machinery (88.06 percent), electricity, gas and water supply (33.34 percent), rubber and rubber products including products from petroleum and coal (32.38 percent), chemical and chemical products (22.34 percent), etc. Most significantly, the rate of growth of output in labour-intensive traditional industries like textiles, food, beverages and tobacco, etc., is, in fact, very low. Output in leather and leather products has actually declined during the period. Employment also seems to have followed somewhat a similar pattern. Productivity growth rate is the highest in the case of machinery except electrical machinery (21.16 percent), followed by miscellaneous industries (15.89 percent), electricity, gas and water supply (11.78 percent), electrical machinery (7.64 percent), etc. Most importantly while productivity growth is impressive only in the case of capital-intensive manufacturing industries, it is very low in the case of labour-intensive industries like textiles, food, etc.; it is even negative in the case of leather and leather products.

13. See Banerji (1975), Goel & Nair (1976, 1978) etc.

Equations 1-4 appearing on pages S8-9 to be read as :

$$V_o = L_o(\Sigma p_{io} q_{io} c_{io}) \quad \ldots\ldots(1)$$

$$V_t = L_t(\Sigma p_{io} q_{it} c_{it}) \quad \ldots\ldots(2)$$

where V = Aggregate output (at constant prices)

L = Aggregate number of persons employed

p_i = Unit price of the output of the i^{th} industry

q_i = Quantity of output from the i^{th} industry per person employed in that industry given by the expression o_i/l_i.

v_i = Output of the i^{th} industry $\Sigma v_i = V$

l_i = Employment in i^{th} industry $\Sigma l_i = L$

c_i = Share of the i^{th} industry in aggregate employment given by the expression l_i/L

Subscripts o and t refer to the base and comparative years respectively. Now, the increment in output between the base year o and comparative year t would be given by

$$V_t - V_o = L_t(\Sigma p_{io} q_{it} c_{it}) - L_o(\Sigma p_{io} q_{io} c_{io}) \quad \ldots\ldots(3)$$

By simplifying and rearranging expression (3), we get

$$V_t - V_o = (L_t - L_o)(\Sigma p_{io} q_{io} c_{io}) \quad \ldots\ldots(I)$$

$$+ L_t \Sigma p_{io} c_{io} (q_{it} - q_{io}) \quad \ldots\ldots(II)$$

$$+ L_t \Sigma p_{io} q_{io} (c_{it} - c_{io}) \quad \ldots\ldots(III)$$

$$+ L_t \Sigma p_{io} (q_{it} - q_{io})(c_{it} - c_{io}) \quad \ldots\ldots(IV)$$

It may be observed that component I above stands for the increment in output due to increment in employment alone, i.e., the increment in output ($V_t - V_o$) from the additional employment ($L_t - L_o$), had the output labour ratio (V/L) remained constant at the base year level.

$$Q_o = V_o/L_o = p_{io} q_{io} c_{io} \quad \ldots\ldots(4)$$

Table 7 appearing on pages S30-31 to be read as :

Table 7 : Average Rate of Growth of Output in Indian Mining and Manufacturing Sectors

MANUFACTURING SECTOR (Percent per annum)

Sl. No.	Industry Group	1951-56	1956-61	1961-66	1966-71	1971-75	1951-75
1.	Food	4.67	7.09	2.61	6.47	(—)0.95	5.85
2.	Beverage & Tobacco	5.05	9.82	8.78	3.42	(—)3.95	6.88
3.	Textile	5.78	1.01	0.87	(—)0.55	6.81	3.12
4.	Leather & Leather Products Including Footwear	0.07	10.33	7.46	(—)9.60	(—)9.99	(—)2.11
5.	Wood & Wood Products Including Furniture & Fixtures	16.59	15.91	14.17	1.17	(—)6.58	14.07
6.	Paper & Paper Products Including Printing & Publishing	8.29	10.16	10.82	0.11	3.68	11.64
7.	Rubber & Rubber Products Including Products from Petroleum & Coal	24.11	11.54	12.69	9.68	0.98	32.38
8.	Chemical & Chemical Products	7.29	16.29	9.21	13.15	1.52	22.34
9.	Non Metalic Mineral Products	11.51	13.48	7.78	6.05	0.64	16.24
10.	Basic Metal Industries	3.75	23.19	11.42	0.94	9.86	20.35
11.	Metal Products Except Electrical Machinery and Transport Equipment	15.62	13.08	(—)0.10	2.03	0.32	9,43
12,	Machinery Except Electrical Machinery	29,15	26,00	32.41	5.17	6.34	93.22
13.	Electrical Machinery	27.65	19.45	21.40	15.60	6.94	88.06
14.	Transport Equipment	23.12	4.09	5.62	(—) 2.46	(—)3.87	6.14
15.	Miscellaneous Industries	7.31	12.02	15.32	2.98	(—)2.08	12.78
16.	Electricity, Gas & Water Supply	9.54	18.40	15.28	9.21	5.79	33.35
17.	Total	8.71	8.15	7.69	3.88	3.49	11.70

(Contd.)

Table 7 (contd.)

MINING SECTOR

Sl. No.	*Mine Group*	*1951-56*	*1956-61*	*1961-66*	*1966-71*	*1971-75*	*1951-75*
1.	Coal & Lignite	2.92	7.22	5.88	1.52	8.98	12.30
2.	Iron Ore	15.82	31.41	6.22	6.95	6.09	38.01
3.	Manganese Ore	3.44	(—)6.42	7.01	(—)2.16	(—)2.58	(—)0.58
4.	Copper	0.85	3.17	0.35	12.18	40.46	17.44
5.	Gold	(—)1.50	(—)4.82	(—)5.68	0.00	(—)4.36	(—)2.44
6.	Limestone	33.97	16.72	25.36	4.54	3.15	32.01
7.	Mica	(—)8.28	(—)0.81	(—)3.55	(—)7.46	(—)6.59	(—)3.27
8.	Others	13.89	34.70	27.93	4.28	1.38	55.14
9.	Total	3.51	8.30	8.32	2.52	6.68	9.84

Table 8 appearing on pages S32-33 to be read as :

Table 8 : Average Rate of Growth of Employment in Indian Mining and Manufacturing Sectors

MANUFACTURING SECTOR

(Percent per annum)

Sl. No.	*Industry Group*	*1951-56*	*1956-61*	*1961-66*	*1966-71*	*1971-75*	*1951-75*
1.	Food	1.78	3.40	1.58	2.49	5.06	17.20
2.	Beverages & Tobacco	4.90	(—)0.64	(—)1.09	(—)2.99	1.37	0.08
3.	Textiles	2.14	(—)0.53	(—)0.91	2.39	2.03	1.51
4.	Leather & Leather Products Including Footwear	5.33	3.15	10.00	(—)2.42	5.60	5.69
5.	Wood & Wood Products Including Furniture & Fixtures	7.57	7.05	7.82	0.42	1.79	7.66
6.	Paper & Paper Products Including Printing & Publishing	2.64	5.16	4.24	2.73	2.52	4.84
7.	Rubber & Rubber Products Including Products from Petroleum and Coal	6.12	4.25	7.37	7.69	4.18	10.42
8.	Chemical & Chemical Products	3.11	8.08	8.22	6.12	5.67	11.11
9.	Non Metallic Mineral Products	(—)1.60	7.97	4.35	3.15	2.58	4.17
10.	Basic Metal Industries	2.16	11.51	9.66	4.62	5.77	12.18
11.	Metal Products Except Electrical and Transport Equipment	5.16	14.62	9.78	(—)1.59	1.35	8.94
12.	Machinery Except Electrical Machinery	5.05	12.09	12.09	1.45	2.77	11.84
13.	Electrical Machinery	6.25	21.44	16.30	6.42	4.76	28.40
14.	Transport Equipment	7.63	5.04	5.25	(—)6.64	4.39	2.98
15.	Miscellaneous Industries	19.44	(—)1.43	5.54	(—)13.25	1.78	(—)0.65
16.	Electricity, Gas & Water Supply	1.62	6.00	5.00	2.15	5.20	5.63
17.	Total	3.04	3.53	4.20	0.95	3.38	3.96

(Contd.)

Table 8 (contd.)

MINING SECTOR

Sl. No.	*Mining Group*	*1951-56*	*1956-61*	*1961-66*	*1966-71*	*1971-75*	*1951-75*
1.	Coal and Lignite	0.03	3.34	0.68	(—)2.03	9.14	2.01
2.	Iron Ore	16.88	9.35	2.13	(—)2.49	0.09	6.75
3.	Manganese Ore	19.59	(—)11.46	0.02	(—)7.07	(—)3.60	(—)2.22
4.	Copper	1.94	0.28	3.24	0.93	29.81	8.10
5.	Gold	(—)3.64	(—)1.78	(—)5.77	1.32	(—)4.77	(—)2.26
6.	Limestone	18.42	15.59	0.36	0.67	(—)1.05	9.13
7.	Mica	(—)6.98	(—)2.55	(—)6.67	(—)7.50	(—)4.59	(—)3.37
8.	Others	10.68	5.32	7.93	2.07	0.47	8.53
9.	Total	2.9 (	1.35	0.84	(—)1.96	5.40	1.65

Table 9 appearing on pages S 34-35 to be read as :

Table 9 : Average Rate of Growth of Output per Employee in Indian Mining and Manufacturing Sectors

MANUFACTURING SECTOR (Percent per annum)

Sl. No.	Industry Group	1951-56	1956-61	1961-66	1966-71	1971-75	1951-75
1.	Food	2.69	3.1 2	(—)3.91	4.61	(—)0.10	1.22
2.	Beverages and Tobacco	0.12	10.81	10.45	7.60	(—)5.04	6.66
3.	Textiles	3.29	1.59	(—)0.03	(—)2.62	4.42	1.18
4.	Leather & Leather Products Including Footwear	(—)4.15	6.18	(—)6.16	(—)8.17	(—)12.75	(—)3.30
5.	Wood & Wood Products Including Furniture & Fixtures	6.56	6.54	4.56	0.74	(—) 7.82	2.26
6.	Rubber and Paper Products Including Printing & Publishing	5.00	3.97	3.14	(—)0.56	1.06	3.15
7.	Rubber & Rubber Products Including Petroleum & Coal	13.79	6.00	3.90	1.44	(—)2.73	6.28
8.	Chemical & Chemical Products	3.62	5.86	0.70	5.39	(—)3.38	3.06
9.	Non-Metallic Mineral Products	14.26	3.94	2.82	2.51	(—)1.59	6.10
10.	Basic Metal Industries	1.44	7.71	0.96	(—)2.99	3.32	2.09
11.	Metal Products Except Machinery & Transport Equipment	8.31	(—)0.92	(—)6.64	3.94	(—)0.99	0.15
12.	Machinery Except Electrical Machinery	19.21	8.66	12.66	3.47	3.21	21.16
13.	Electrical Machinery	16.32	(—)0.96	2.66	6.96	1.83	7.64
14.	Transport Equipment	11.21	(—)0.76	0.30	6.26	(—)6.98	1.84
15.	Miscellaneous Industries	(—)6.16	14.57	7.66	48.13	(—)3.61	15.89
16.	Electricity, Gas and Water Supply	7.32	9.54	8.22	6.37	0.49	11.78
17.	Total	4.63	4.21	2.89	2.80	0.10	3.97

(Contd.)

Table 9 (contd.)

MINING SECTOR

Sl. No.	Mine Group	1951-56	1956-61	1961-66	1966-71	1971-75	1951-75
1.	Coal & Lignite	2.90	3.33	5.01	3.96	(—)0.11	4.13
2.	Iron Ore	(—)0.57	15.16	3.70	10.79	5.99	11.93
3.	Manganese Ore	(—)8.15	11.82	6.97	7.59	11.88	3.48
4.	Copper	(—)1.00	2.54	(—)2.22	10.76	4.86	3.12
5.	Gold	2.61	(—)3.33	0.12	(—)1.24	0.47	(—)0.39
6.	Limestone	8.11	0.63	4.91	5.64	4.39	7.18
7.	Mica	(—)2.00	(—)2.00	4.70	0.11	(—)2.46	0.47
8.	Others	2.14	23.22	14.33	2.03	0.88	15.30
9.	Total	0.54	6.52	7.18	4.97	0.92	5.82

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Organisational Effectiveness and Human Resource Development

K. D. Madan*

Organisation and its Effectiveness

Any organisation with an objective or goal to achieve, would have four essential resources, namely, human, physical, financial and information, with which to achieve it. Within each category of resources would be several varying types. For example, human resources include people with varied interests, abilities, skills, aspiration levels and characteristics. Physical resources would include an organisation's physical assets like its plant, office buildings and the land appertinent to it, tools and other equipment, raw materials, energy sources and goods in various stages of finish. Financial resources include cash, credits, a budget allocation and so on, which an organisation uses in the acquisition and utilisation of other resources. Information consists of data, ideas, reports, etc., which are generated internally or externally and which inform the organisation as to its inputs, the technology involved in the transformation process and the quality and quantity of its outputs.

The transformation process adds value to the inputs. It may involve manufacture of goods or production of services. In either case, the transformation process is influenced by the way the organisation has structured itself, its policies and procedures, the rules it has developed to run its day-to-day operation, the method and quality of its decision-making process in allocating, utilising and renewing its resources, and the overall planning, organising and developing of the skills of its men and managers. It includes the behavioural climate of the organisation inasmuch as the latter affects motivation, commitment, morale and productivity. Organisational development programmes and processes including its training and education efforts for its personnel are a part of the strengthening of the transformation process.

While each of the four resources is a key resource, the most important of them all is the people in an organisation or the human resource. This is

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The views expressed are those of the author and not of the institution to which he belongs.

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social systems and socio-economic environment of the country. Since in the long run it is the members of the organisation, that is, its own employees, whose behaviour would either facilitate or inhibit the organisational goal attainment, it is they who would influence the effectiveness of the organisation. An awareness of the nature of individual differences among the members of the organisation and the need to tailor the effectiveness approach so that they are led in that direction, would clearly improve the chances of cooperation and mutual support among them, and ultimately of organisational benefit. The integration of employees' personal goals with organisational objectives as a means of securing cohesion and ironing out conflicts is thus obvious. Similarly, among managerial policies and practices which could enhance and sustain the effectiveness of organisations must be mentioned measures like strategic goal setting, efficient resource acquisition and utilisation, creation of a performance environment, effective communication processes, leadership and decision-making, and organisational adaptability and innovation. Thus, any evaluation of organisational effectiveness would include its capacities

* to provide work satisfaction, individual development and quality of life to its employees;

1. Richard M. Steers in his book, *Organisational Effectiveness—A Behavioural View.*

so because it is through this resource that all the others are deployed, utilised and generated. It is through people that physical and financial resources are acquired. People generate data and analyse it to provide information. In brief, it is people who transform all other resources into outputs. And if there is a task which the organisation has set for itself, eventually, it is the people in the organisation who must accomplish or fail to accomplish it.

Herein comes the concept of effectiveness as far as an organisation is concerned. To the extent an organisation is able to accomplish the goal or goals which it has set for itself, to that extent it would be effective. Effectiveness, of course, is not the same thing as efficiency. A clear distinction exists between the two concepts. Effectiveness is concerned with whether a given goal or objective has been accomplished but not necessarily with the cost of accomplishment of the objective. On the other hand, efficiency is concerned with the cost of achieving a certain goal. This paper is based on th

* to integrate employee goals into organisational goals;
* to provide effective service/satisfaction to its clientele;
* to adapt itself to the changing environment;
* for development and growth;
* to exercise a positive moral and socio-economic influence on the community; and
* to fit in the national as well as global commitments.

It would be pertinent to mention here that no single set of criteria can, *per se*, be prescribed for measuring the effectiveness of organisations, in general. Organisations vary according to size, systems and objectives. The uniqueness of each organisation, its goals, structure, technology, people, environment, etc., have to be acknowledged and efforts made to identify the standards of evaluation of its effectiveness consistent with that uniqueness. In other words, one cannot prescribe any general or universal criteria for achieving organisational effectiveness. Given the diversity of organisation in our contemporary world, any such criteria would have only a very limited and theoretical value.

Also, the concept of organisational effectiveness is an on-going and continuous process instead of an end state itself. Since the conditions which determine effectiveness and the environment in which the organisation functions are continuously changing, an organisation which may be effective at one time may cease to be so later. The search for criteria, or determination of the level of organisational effectiveness, therefore cannot be a once ever effort.

Energising, directing and assisting goal-oriented efforts of employees thus become an unceasing task for the management which carries a continual responsibility to harness available resources to the optimum level, adopt and adapt the most suitable technology, create work-conducive climate and develop its employees with a view to attain organisational goals. It is here that the manager emerges as the prime facilitator of organisational effectiveness through human resource development.

Human Resource Development (HRD)

Human Resource Development(HRD)in an organisation means a process of purposive maturing of its employees and nurturing in them a will to learn, to grow and to acquire a desire for new perspectives towards their work and the people with whom they deal in order to attain organisational goals. The scope of HRD is wider than personnel administration. It encompasses in its fold efforts which aim at achieving improved performance and job satisfaction, better inter-personal relationship resulting in enhanced efficiency and overall effectiveness in the organisation. It devolves on the top management to initiate the process of maturing of its employees, since imparting of new skills to its employees and affording them the opportunity to learn and to change their attitude to work accomplishment not only enables the employees to integrate their personal goals with those of the organisation but also enhances the possibility of the organisation achieving its goals at a lesser cost.

The concern for HRD is not of recent origin even though the term is relatively new. Economists like Marshal and Pigou did lay emphasis on its significance in human activity. Marshal stressed the importance of education as 'national investment' and said that "...the most valuable of all capitals is that of investment in human beings." Later economists and management scientists who became more embroiled in capital-output ratios and immediate returns tended to relegate education and training as a 'social welfare expense' secondary to the more important physical capital investment. It is only with the passage of time that the realisation began to dawn on planners, economists and entrepreneurs that in any human effort involving organisation, it is the human resource which must get the pride of place.

Conflicts

Chalking out an effective HRD strategy is not an easy task as there are various conflicts encountered which need to be resolved. These are essentially economic in character but to an extent also political and social in nature and are to be encountered at various levels of decision making.

First comes the question of allocation of resources for investment as

between the human capital and the other alternative areas like the physical capital. Until quite recently, adding to the stock of physical capital often dominated most investment decisions. In course of time, realisation grew that an excessive reliance on the accumulation of physical capital led speedily to diminishing returns unless correspondingly, the human resources grew and developed so as to be able to tackle the physical capital of an organisation; and, in fact, but for HRD, the growth of physical capital itself would have been thwarted due to deficiency in knowledge, managerial skills and the required motivation. Investigations by Harbison and Mayers of Stanford revealed a high positive correlation between HRD and indicators of economic development. Schultz—the 1979 Nobel Prize winner in Economics—has also corroborated this and said that 21 percent increase in the national income in USA between 1929 and 1957 was the contribution of education.

Another argument often advanced is that the need for a high rate of investment in human capital arises only at a fairly advanced state of economic development and in support of this is cited the industrial growth in western Europe where much was accomplished without requiring as a pre-requisite, marked improvements in skills and knowledge. In furthering this viewpoint, however, the host of problems—social, political and economic—which the western world faced seem to be conveniently forgotten as also the fact that if the developing countries have to catch up and take the fullest advantage of the complex equipment and technology, then a relatively high level of skills and knowledge would be a concomitant. What is even more important is that the changes in social and cultural climate and the widening of horizons during the recent decades not only make investment in human capital inescapable but by themselves provide 'external economies' which any cost-benefit analysis must take into account. From this view point, returns from education would be comparable to any other form of investment.

At the national level, other conflicts arise with regard to the choice between functional and formal education, between primary and secondary education, between education in science and technology and arts and humanities, or between education—scientific and technical—available indigenously and abroad. In all of these, a balance has to be struck and the choice, wherever required to be made, must depend on the circumstances prevailing at the time.

Finally, it is the conflict between the interests of the state and those of an individual. From the state's point of view, any investment in the field of education must enhance the usefulness of an individual in economically productive fields which, in turn, could contribute to the political and economic prowess of the state. On the other hand, from an individual's point of view such an investment should enhance his freedom, dignity and most of all, his worth. Here also one is faced with the problem of striking a careful balance which takes into account the socio-political system in force.

HRD in the Context of Developing Countries

Managerial policies and practices cannot be transferred bodily from the advanced economy setting—where unfortunately most of them have been developed to the developing countries. Management and manpower in all their layers, are fairly culture-bound and any indiscriminate and wholesale use of western management know-how and its instruments for evaluation may lack validity in developing countries. This points to the importance of guarding against adoption of any management instrument and technique except with due care to the particular need, cultural milieu, level of development and the employee-need pattern which an organisation in a developing country requires. According to Price, "... the most serious present need is for studies of non-American and non-western organisations. It is impossible to develop a theory of effectiveness of organisations with studies performed almost exclusively in the United States."[2] The picture today in most countries, particularly developing ones, is that though endowed with plentiful raw and untrained human resource, they lack in trained and specialised manpower to carry out the tasks of development and planning. These countries are confronted simultaneously with a seemingly paradoxical and conflicting problem. On the one hand they have surplus labour in both the modern and traditional sectors, and on the other, they suffer from acute shortage of skilled manpower needed for their development effort. It is the mismatch of the skills available and the job requirements that results in this paradox and for an attack on this problem, HRD assumes greater relevance for these countries.

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2. James L. Price, *Organisational Effectiveness.*

HRD as a planned strategy must not only aim at acquisition and utilisation of human resources in an organisation, but at improvement of their potential. For this purpose, a planned HRD would involve

* establishment of proper organisational structure and planning of organisational development;
* qualitative and quantitative assessment of skills;
* planning and execution of sound recruitment, placement, training and promotion policies;
* formulation of a wage structure, easy to understand, simple to implement, and service conditions acceptable to workers;
* appreciation of the work environment including physical conditions of workers;
* evolution of standard norms for appraising the performance of workers;
* introduction of employee motivation, careful carreer planning and development and cultivation of constructive and meaningful labour-management relations to improve labour productivity and achieve industrial harmony and peace.

To sum up, the management must procure and organise the human element of its resources based on a correct assessment of manpower requirements in various skills, prepare a correct job description for each job, assign the right job to the right man, induct and train every person in the right manner, and finally, motivate every employee to work for the organisation and to consider it his own.

HRD in the Governmental System

Human resource development in government is a highly complex task anywhere. In India in particular, not only because of the size of the country and its population but also its adoption of economic planning as an instrument of public policy and development efforts, the governmental functions have diversified enormously, especially after independence. The governmental system is thus, not only complex in nature but is vast in size and pervades innumerable walks of life. It comprises a number

of sub-systems, each generally self-contained and independent in nature, with not much co-ordinative interaction with other sub-systems, but broadly interwoven with the fabric of the main system so far as the national aims, objectives and policies are concerned. With each sub-system in government having a separate entity, the organisational effectiveness of each and the degree of its goal achievement, requires evaluation in terms of the aims and objectives of each department or ministry of the government. In turn, the measure of success in terms of goal achievement of each of the departments of the government must be integrated into the overall success of the government as a total system set on its basic objectives. While the parameters of organisational effectiveness, internal and external environment, as well as the demands and aspirations of the employees working in each department of the government would be different, their synchronisation with the entire apparatus of government is necessary so that no single sub-system is entirely out of tune with the others.

The policies of the government are translated into action through its executive machinery according to well-defined and laid down methods and procedures of work. The basic aims and objectives, and the principles governing the system of the government are enshrined in the Constitution. Within this constitutional framework, the pendulum of government activity may swing within limits influenced by political ideology of the party in power. The size of the country, its total population, socio-economic conditions, standard of living of the people and the requirements of the developing economy have their inevitable influence on the size, nature and content of the public administration.

The manifold goals of national planning call for a large, honest, dynamic, effective administrative force with decentralised authority to solve its multifarious problems. The total approximate strength of regular employees in the central government sector (excluding quasi-governmental establishments) as on 31st March 1978 was of the order of 3.2 million. This represented an overall increase of somewhere over 2 percent per annum during the previous two years, the corresponding figure for 31st March 1976 having been 3.045 million. Table 1 gives ministry-wise distribution of this population and indicates the diversified fields of governmental activity in which more than 3 million central government employees are involved.

Table 1 : Strength of Regular Central Government Employees as on 31st March 1978

(in Thousands)

Name of Ministries/Departments	*Number*
Agriculture and Irrigation	25.7
Atomic Energy	20.3
Cabinet Secretariat	5.5
Chemical and Fertilisers	0 2
Commerce	6.8
Communications	495.0
Culture	6.2
Defence (Civilians)	519.5
Education and Social Welfare	2.8
Electronics	0.3
Energy	6.9
External Affairs	4.4
Finance	152.5
Home Affairs	196.8
Health and Family Planning	17.5
Industry and Civil Supplies	24.5
Indian Audit and Accounts Department	65.7
Information and Broadcasting	18.7
Labour	9.7
Law, Justice and Company Affairs	3.6
Petroleum	0.3
Planning	22.0
Railways	1495.0
Shipping and Transport	5.5
Space	8.4
Steel and Mines	10.2
Supply and Rehabilitation	15.8
Tourism and Civil Aviation	16.3
Works and Housing	39.3
Other Departments	6.1
Total	3201.5

From the size of the central government employee force, the area of their activities and their dispersal throughout the country, one can visualise the massive scale of effort in which they are involved and the enormity of the problems which they have to cope with. This firstly points to the need for a vast manpower to acquire new skills and knowledge and information about the latest developments in their respective fields in order to discharge their functions competently and effectively. Secondly, as a vehicle for translating people's needs and aspirations into a reality, the public administration has to be more receptive to public requirements and must reckon with healthy criticism and feel accountable in order to produce effective results.

Therefore, if any success has to be achieved, then the public administration in India will have to measure up to the following expectations :

* It should be capable of solving the enormous problems created by the size and population of the country.
* It should be capable of adjusting itself to the diversity of the country by improvising local adaptations of national policies, programmes and administrative structures.
* It should possess the capabilities required to meet the needs of planning, development and growth.
* It should ensure the highest standards of efficiency and integrity in public services.
* It should ensure adequate and quick response to the needs and aspirations of the people.

If this, is the desideratum of the system of public administration in a country of the size and diversity as India, and if the system has to deliver the goods competently and effectively, then the need for a proper and scientific plan for the human resource development of the large employee force of the public administration system is obvious.

Equally obvious becomes the need for greater professionalisation among the civil servants. It is not merely academic knowledge that they must acquire and possess but also skills to be able to apply the various tools and techniques of management in order to make sound decisions, especially in the areas of resource allocation and its utilisation. This

involves the choice of suitable men and developing in them capacity to imbibe conceptual, technical and human relations skill apart from the technology relating to their functional areas. This will be possible only through a well-designed personnel policy embodying appropriate executive training programmes.

In the Government of India, it is the Department of Personnel and Administrative Reforms which is charged with the responsibility of personnel management in the government and introduction of administrative reforms to improve the capabilities and effectiveness of the administrative machinery. In furtherance of its role, it has taken several steps to refashion personnel policies relating to recruitment and placement of employees, streamline and improve cadre structures, provide welfare amenities to its employees, simplify service rules and procedures and organise training facilities for different groups of employees. Among developments which have taken place in recent years in personnel policy directed towards enhancement of productivity, morale and work satisfaction among civil servants, may be cited modification in the system of examination for recruitment to all-India services, to reviews of cadre structures and revamping of the performance appraisal of officers. Most important of all is perhaps the preparation of inventories of executive personnel listing essential bio-data of each individual executive with his academic qualifications, nature of training received by him, a chronological record of the various assignements held and an appraisal of his performance on the one hand and of all jobs including responsibilities and functions of each and the academic qualifications, skills, training and personality traits deemed essential for performing the job on the other. With inventories being easily retrievable, this step has led to increased matching of employees' qualifications with the job requirements and their placement in various positions on scientific lines as also a proper career planning for their future advancement. This is, however, only a beginning and much remains to be achieved in this direction.

The five-year plans and other documents lay considerable emphasis on training so that personnel engaged in various fields of work develop right attitudes, improve their decision-making abilities and get attuned to creative and innovative thinking. It should be noted that through systematised training of the employee force walls of traditionalism would be broken and an innovative and adaptive culture, so essential for the

country's growth, would be generated. It is realised that, for any training programme to be effective, it should not only aim at integration of employees' individual aspirations with the organisation's goals but should be related to the actual work environment. Such training must also have in it the in-built characteristic of so priming up the trainees that in course of time they develop the habit of self-learning and self-development.

During recent years there has been a rapid expansion in training facilities available to government employees with a separate Training Division in the Department of Personnel and Administrative Reforms. At present each cadre has its own training institute where a sandwich-pattern training based on a mix of theoretical inputs and practical insight based on field experience is imparted to the executives. This training is not limited to new entrants in service but extends to orientation and refresher courses at various levels as also to on-the-job training related to work environment.

Some time ago, the Department of Personnel and Administrative Reforms undertook a general review of the training policy of the government personnel with a view to drawing up a systematic plan to cover employees of all categories for the next five years.

Basic features of the plan as evolved are :

* Induction training of a suitable duration for all new entrants to service.
* Institutional training arrangements to be made for all established central services.
* Specialised in-service refresher training programmes to be arranged for all levels of officers.

As a part of this training plan it has been decided that while the functional training institutions concerned with various cadres should concentrate on arranging professional and functional training for the respective groups, the training division of the Department of Personnel would undertake to conduct programmes like executive and management development programmes which reflect a common training need for several departments and involve adoption of an inter-departmental and inter-disciplinary approach.

Conclusion

The development — or rather the lack of development — of human capital in the past is being increasingly brought into focus particularly in the setting of developing countries. An effective HRD strategy, it is now realised, is essential for development, whether it be for an organisation at the micro level or the national economy at the macro level. Indeed, in developing countries, the shortage of capital on the one hand and the availability of large labour force on the other impart greater urgency to an appropriate planned strategy.

Prescribing a uniform set of criteria for measuring effectiveness and an HRD strategy which would be universally applicable is not possible. Each organisation or economy has to lay down each of these for itself. That development hinges more on tapping the human fund than on any other type of resource is, however, undoubted.

An HRD strategy must take into account factors such as the prevailing socio-economic forces, the other relevant circumstances existing at any point of time and the objectives which the organisation or the economy has set for itself. □

Training Function and Management Information System

M. M. Jacob*

In-company training in our country is getting more and more popular and many companies nowadays give due importance to this personnel function and provide sizeable budget towards the same. This activity is carried out both as a welfare activity and as an input factor to profitability and growth. Even though it is accepted as a useful and valuable service in management circles, the involvement of various levels of managers in this important function of personnel development is somewhat superficial. This is primarily so because no manager can quantify the contribution of the training function to the overall objectives of profitability and growth. Moreover, the information flow in this field is too meagre and, consequently, the effort put in arriving at right decisions pertaining to this activity is too negligible.

If we are to improve upon the value and importance of the training function, it is necessary to set up an effective decision making apparatus which would involve the participation and commitment of not only the top management, but also the senior managers of various departments. This is because training is primarily a service function to meet the requirements of the various departments of an organisation. For this the decision managers should have necessary information at appropriate time. Management Information System is primarily designed to provide the information needed by managers to take decisions and to effect controls.

Personnel Development is a part of Personnel Management and has to be an integral part of the MIS for Personnel Management where specific slots are designed to meet the requirements of training function. For instance, the performance evaluation format can be modified to suit the requirement of the training function to determine the specific training needs of an individual employee. Therefore, MIS needed for the training function cannot be thought of in isolation, *vis-a-vis* other functions. The main objective of a training function is to prevent the obsolescence

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of the employees in an organisation by updating their knowledge and skill needed for efficient discharge of their functions. This objective can further be sub-divided into the following according to the groups of employees :

1. *Newly Recruited Employees* :

   a) To familiarise the new employees with the organisation, its policies, rules and procedures, their job etc. (Induction programmes).

   b) To Impart the basic job knowledge and skill needed to perform the basic functions of the job (Technicians and Engineers Apprenticeship Programmes, Operatives Trade Programmes, Management and Executive Training Programmes, etc.)

2. *Existing Employees (Operators/Trade Men)* :

   a) To refresh the knowledge and skill already acquired (periodic skill tests and programmes for drivers, welders, inspectors, firemen, security guards, etc.).

   b) To update the knowledge and skill on the job done (refresher programmes to familiarise with new developments in the field).

   c) To provide new or additional knowledge and skill needed by the employees when they are put on new jobs due to promotions, transfers, etc. (basic job training programmes).

3. *Existing Employees (Supervisors)* :

   a) To impart basic knowledge and skill needed to do supervisory duties (basic programmes to the employees promoted to supervisory jobs).

   b) To bring out desired behavioural/attitudinal changes (T-group programmes, Sensitivity programmes, Communication and Group Discussion etc.).

   c) To update the knowledge and skill (refresher programmes to acquaint with new production/operation methods, procedures, policies and rules, etc.).

4. *Technicians/Engineers/Specialists :*

   a) To impart basic knowledge and skill in some important techniques when employees are put on new jobs/duties (basic training programmes in particular techniques—basic programmes in Programming, Tool Design, Planning, Materials Control, Cost Control, Maintenance, etc.).

   b) To update the knowledge and skill (refresher programmes in the particular technology when new advances and developments and changes are to be introduced).

   c) To familiarise with new areas of knowledge to enable them to search and select appropriate technology (appreciation programmes to determine the suitability of the new techniques/methods developed elsewhere).

5. *Managerial Executives :*

   a) To impart the basic knowledge and skill to the newly recruited or promoted people to the managerial cadre.

   b) To impart the basic knowledge and skill needed in specific functions when people are transferred or promoted to those functions.

   c) To update the knowledge and skill (refresher programmes in new developments as and when the need to introduce such developments in the organisations are felt, e.g. MBO, Corporate Planning, MIS, EDP, Performance Budgeting, Productivity Bargaining, etc.).

   d) To familiarise with new areas of knowledge and developments so that managers get the opportunity to select suitable developments in various fields of management (appreciation programmes).

   e) To develop behavioural pattern through attitudinal developments (programmes like O.D., T-Group, Sensitivity Training, Leadership Training, etc.).

To discuss about the design details of an MIS is beyond the scope of this paper, yet it may be worthwhile to know how MIS is used to develop plans for achieving objectives, to organise for implementing the same and to

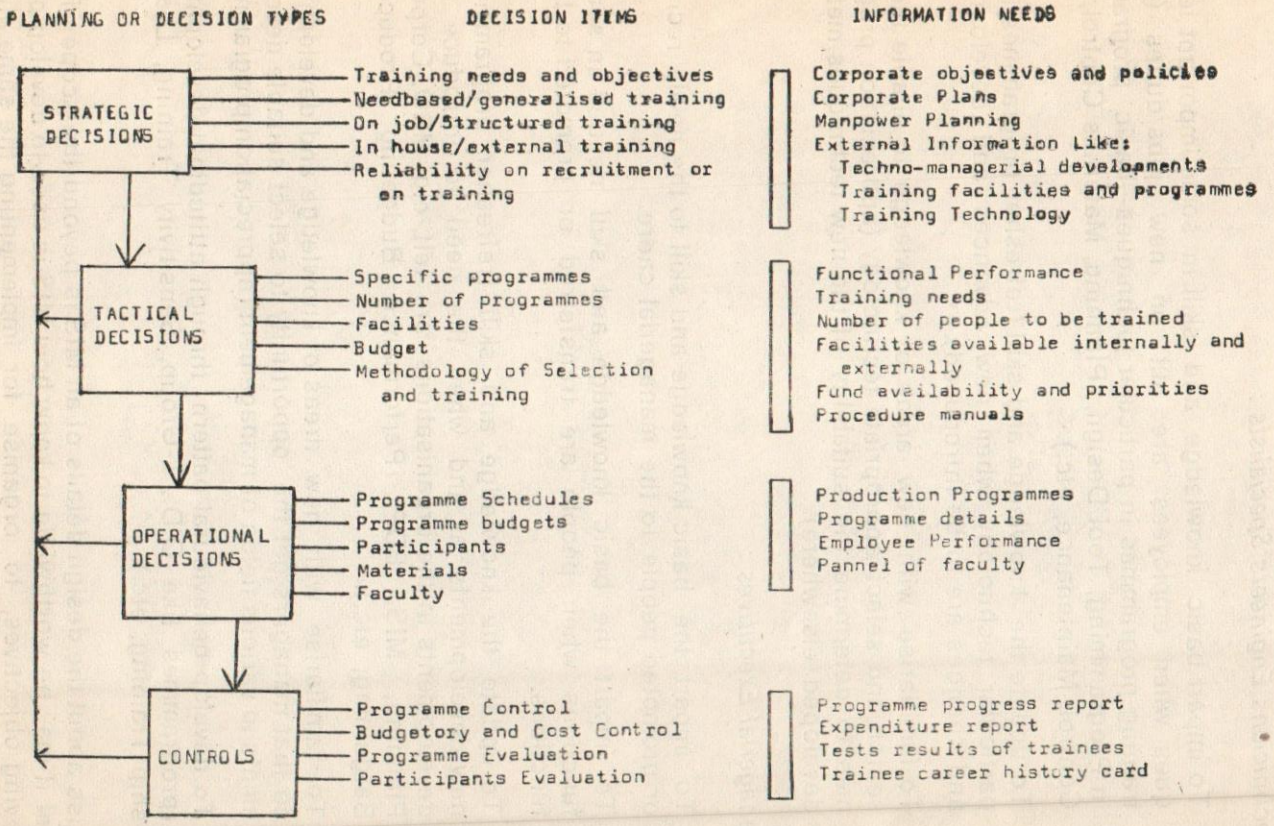

Fig. 1

Note : Decisions made at higher level of planning are information needed for lower level decisions.

control performance so that plans and actions take place on schedule. Information on these enable the managers to fulfil the goals. The communication network and the procedure adopted to provide such information to line managers is called Management Information System. MIS integrates all organisational activities through exchange of information which consists of orderly, selected, summarised data useful for managerial decisions.

The decisions involved in fulfilling the objectives of the training function can be grouped as in the case of any other managerial function into strategic, tactical and operational and control decisions. The examples of the decisions involved and the information needed are given in Fig. 1.

An MIS for training function should provide the selected information on the following matters to the managers as and when needed by them in decision making :

i) Training objectives, policies and training function responsibilities.

ii) Job specifications and training needs, category-wise.

iii) Training programmes registry.

iv) Training institutions registry.

v) Procedure for the assessment of training needs.

vi) Plans and budgets of the training.

vii) Procedure for selection of the employees for training.

viii) Evaluation of the training.

ix) Evaluation of the trainees.

x) Trainee career history.

xi) Training department's performance.

To design and instal a computerised type MIS for training function at the present juncture may not be feasible because the base needed for the same is not available in our industries. Considering the need for a reasonable information system and the difficulty to quantify the end results, it may be worthwhile to search for a simplified, yet a practical approach.

Recent years have seen a growing interest in a new tool of management, sometimes referred to as "Programme Budgeting", or "Performance System". In essence, this is a method of casting the budget of a department in a way that the entire budget is distributed among a number of specific programmes, a programme being defined as an activity that has a unique objective. Here, the classification of objectives as mentioned above, can be of help. The purpose of such a budget format is to permit measurements of the success or failure of the various programmes in attaining stated objectives.

Performance budgeting is simply an analysis of cost-effectiveness confined to the broad functional objectives of the programme that makes up a departmental budget. This is an effective system where the overall objective cannot be quantified and measured very easily. The attempt to introduce programme budgeting system must, on its own, lead to more explicit delineation of goals and provide an acceptable framework for decision making in the field of training in the light of stated objectives, which must be accomplished. □

In-Company Supervisory Development Programmes

M. V. V. Raman*

Introduction

Experience of developed countries have shown that the level and the content of development of a nation's supervisory skills determine and sustain the growth of industrial (and other organisation's) productivity. The following statements made by Presidents of three American companies bring out the importance of the position held by the Supervisors in an organisation, and the need for their continuous training and development :

> "He is the man responsible for day to day efficiency and economy in manufacturing programmes. He is the man who must know his product, processes, and his people."—*Walter Sheaffer II President, W. A. Sheaffer Pen Company.*

> "It is the 'new' foreman— thoroughly trained in his job and made aware of its consequences—who makes possible the achievement of maximum results by merging men and machines. Here, at the first line, is where the battle for world markets will be won."—*Henry Harnishfoger, President, The Harnishfoger Corporation.*

> "It is important, then, for the foreman to be provided all the tools of modern, progressive management. He must have adequate training, sufficient authority to supervise, the firm support of his higher management, and —perhaps most important—he must be regarded by his superiors as a valued member of management."

> "The management job gets tougher each year. Top and middle management, occupied full time with financial matters, product improvement and promotion, the problems created by restrictive legislation and aggressive labour organisations, and the day-to-day conduct of the business, must rely more heavily on foremen and other direct supervisors. Management must have competent and professional foremen and must be prepared to spend their time,

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money, and effort to get them."—*Dwight P. Joyce, Chairman, Glidden Company.*

A supervisor or a foreman occupies a key position in any organisation, providing a direct link for transmitting ideas of productivity from the upper echelons of management to the workers, and what is more important, ensuring their implementation on the shopfloor or office. Nothing is more detrimental to the cause of productivity than a weak and ineffective supervision.

A supervisor can consider himself competent only when, besides a thorough knowledge of his own job, he possesses the necessary skills to ensure organised team-work for attaining the objectives set before him. In this task, he must be clearly aware of his authority as well as responsibilities. The necessary attribute for achieving the desired results is to promote and maintain discipline and to motivate the workers through proper guidance, demonstration and training to respond to the challenge of the ever-growing and varying demands of an organisation. A modern supervisor has to maintain constant surveillance over cost and quality. To sum up, a supervisor should be proficient in technical and managerial skills, which include social skills for organising, planning, controlling, motivating and instructing the workers placed under his care in a shop or at work centre or office, for achieving the objectives set before the team.

Indian Experience

The experience over the last two decades regarding supervisory practices in Indian industries has revealed that the concept of supervision has not been clearly understood or appreciated. Some of the deficiencies observed are : lack of technical content in supervision, lack of cost consciousness, passive and routine supervision as opposed to positive supervision to improve in terms of quality, quantity, cost, safety, delivery etc., lack of ability to interact with other staff functions in the organisation, and most importantly, lack of ability to adjust to the changing circumstances, particularly in terms of getting work done by others. The result has been to develop the concept of total supervision for propagation among the Indian industries and other organisations. The supervisory development training should be designed around the technical content of

the supervisor's job adding elements like managing the job, managing the people, and interacting with other staff functions.

Structure of Supervisory Training

The conceptual framework for the structure of a Supervisory Training (ST) may be visualised by posing questions like :

Who are supervisors ?

What do they do ?

What are they responsible for ?

What can Supervisory Training do for them ?

What should be the contents of Supervisory Training ?

(i) Who are Supervisors : Broadly speaking, anyone who is responsible for the work of others, i. e., one who supervises the work of others, is a supervisor. Thus in an industrial set up, there are larger number of supervisors, and depending generally on the nature of work, responsibility and authority, they are classified according to 'level'. The various levels are represented in Fig. 1. The size of the company will generally determine how this division can be made.

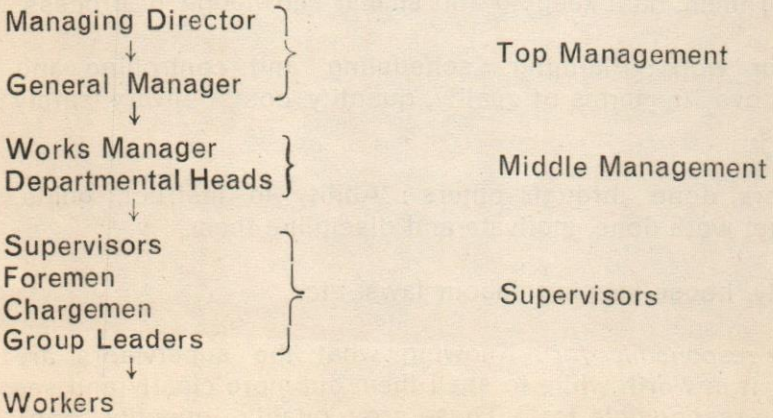

Fig. 1. Line Organisation

Basically, as one moves up to the level of middle management, this group is less concerned with daily routines, and is more concerned with future plans and programmes and other developments.

The top management group is, by and large, concerned with long-range planning, policies, procedures and evaluation of results.

In the development of ST, one should be concerned with the supervisory groups who will be responsible for the day-to-day work, and who generally work according to given policies, procedures and practices. Such a clear-cut classification is not possible in all cases, particularly in the medium and small scale industries. In such cases, even departmental heads may come under the category of supervisors, who look after the day-to-day work.

(ii) What do they do : These persons do not actually do the job (as done by operators and workers), but are generally responsible for planning, decision-making, control and communicating (including reporting) everything pertinent to their level. This involves 'management' as is understood in the modern sense. Briefly, this means that a supervisor should know :

(a) Technical aspects pertaining to his job : The theoretical technical background of the product that is under manufacture and particularly the section or department he works in. The processing details, machinery, speed, settings, temperature, pressure, etc., as to why things may go bad, ways of correcting them, data keeping and similar knowledge of process.

(b) Organising for work : Planning, scheduling and controlling and continuously improve in terms of quality, quantity, cost, delivery, safety and similar factors.

(c) How to get work done through others : Ability to instruct, guide, correct, control, get work done, motivate and discipline them.

(d) Others : Safety, house-keeping, labour laws, etc.

(iii) What are they responsible for : Knowing what the supervisors are expected to do, it is worth while to spell them out more clearly and see the things they are responsible for. These are : quality, quantity, cost, upkeep, improvements, supervising people under them, reporting to

seniors, co-operation and co-ordination with colleagues at his own level, co-operation and assistance to staff functions (quality control, work study, etc.).

Thus, it is seen that the supervisor, as a person proficient in the technical aspects of his job (theory and practice), uses the resources effectively, suggests improvements, provides leadership to subordinates, keeps his seniors (higher-level management) informed and assists in the implementation of accepted recommendations from other specialists. The full visualisation of a supervisor in industry is shown in Fig. 2.

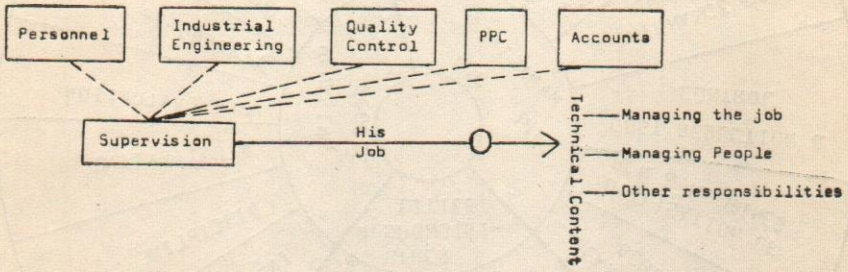

Fig. 2. The Supervisor

(iv) What can Supervisory Training do for them : In view of the above description of a supervisor's job, one should design a programme which has clear-cut objectives. These objectives can be :

(a) To make the supervisor a better supervisor ;

(b) To develop him for assuming higher responsibilities (vertical mobility).

One point needs emphasis here. The technical aspects of a supervisor's job must be learnt prior to assuming duty, which he must have aquired in schools, colleges and technical institutions. Though Supervisory Training throws little light on this aspect, it does help a supervisor to develop skill for organising and supervising people.

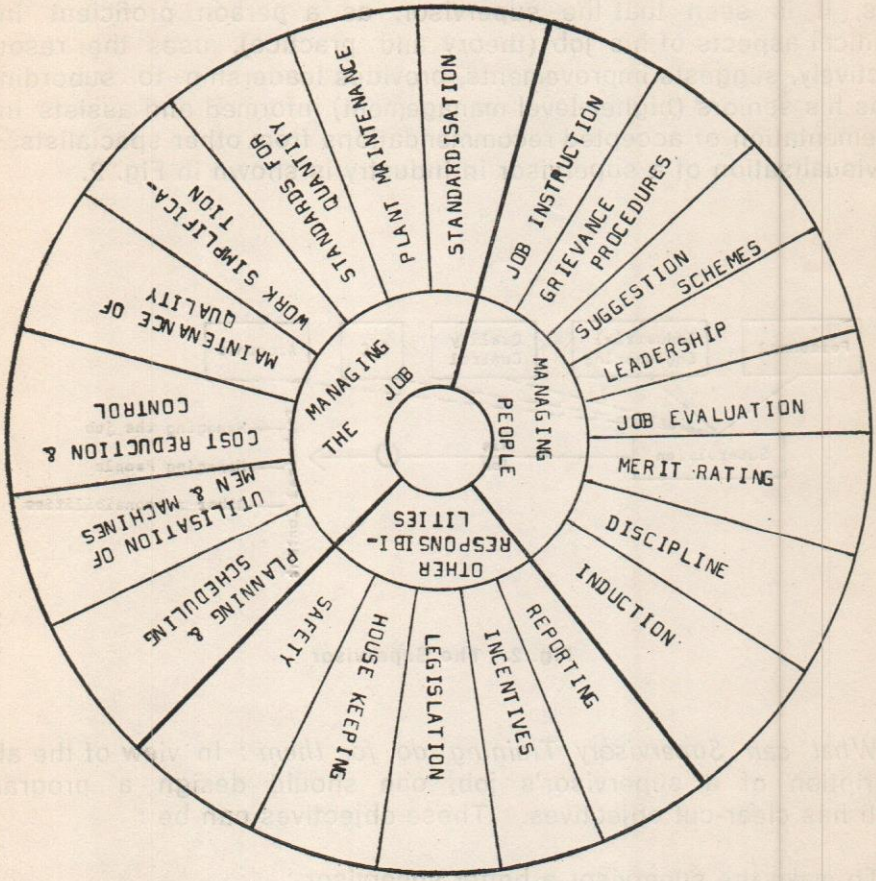

Fig. 3 : Conceptualisation of Supervisor Training Programme

In order to satisfy the requirements of (a) and (b), Supervisory Training should provide knowledge and information which would improve the supervisor's ability to manage the job and to direct his subordinates more effectively. It should also prove instrumental in the enlargement of the perspective from the narrow department-oriented outlook to that of overall organisational requirements and needs.

(v) What should be the contents of Supervisory Training : In addition to the topics mentioned above, the emphasis under Indian conditions should be to increase the 'technical content' of supervision to emphasise the role of supervisor in cost reduction, and to motivate people working with him. He should know his 'job' thoroughly, i.e., technical content, managing the job and managing people.

Supervisory Training is visualised as a strong fort built on the solid foundation of understanding of the technical content of the job of a supervisor. It makes the supervisor strong, confident in his day-to-day work and capable of achieving the objectives set by the management effectively. This concept is explained in Fig. 3.

Infrastructure Factors

Other aspects that have come to light regarding the environment in which supervisors work are :

(i) The top management interest and involvement not only in terms of training but also in terms of development concerning performance are not apparent or not readily perceivable in the eyes of the supervisors.

(ii) The supervisory training and development functions have been mostly the responsibility of the Training Department or Personnel Department; the line manager has not taken interest in these areas (training and development), and most important, it seems they have not considered it as their job.

(iii) Though the supervisors perform the management functions, they are not generally considered as belonging to the management team.

(iv) Managers have not really appreciated the need to provide satisfaction

to the supervisors in terms of making their jobs challenging and having meaningful performance appraisal. The attitude of top management and other senior managers towards supervisors, whatever be the reason, has not encouraged supervisors to consider themselves as part of the management, and in fact, has driven them more towards workers.

(v) Under the existing set up it has to be appreciated that supervisors cannot discharge at will whatever be the opinion of senior management personnel regarding their efficiency and attitude towards them. Therefore, the management has a responsibility to win their support through appropriate methods and behaviour.

(vi) The first-line and other levels of supervisors stand between the workers and the management in matters of policy implementation as a link in many forms of communication and also for improving motivation. The need for more better and direct communication feedback from the lines to the highest echelons is very important. At present the inability to interpret the company policies to the workers has been one of the major hindrances in getting work done or motivatiing the workers or earning their respect.

(vii) Further, supervisors come into organisation either from colleges and universities or through promotion from the ranks. The new educated entrant mostly learns about supervision by trial and error and following old practices which may not be conducive to effective supervision. The supervisors coming from ranks, continue to carry their own understandings of supervision and in many cases exhibit worker orientation than management orientation. Management intervention to remedy this situation is vital and necessary, which is not very well recognised.

(viii) Learning and practising about good supervision is a complicated matter which cannot be learnt in one training exercise or a book. Hence the need for involvement of all concerned in the practice of the same is essential.

Programme

Taking into consideration the above factors, the National Productivity Council has developed a supervisory development programme. This is

called a programme because it is not merely a training exercise but also incorporates various approaches for creating an impact through top management involvement, manager involvement through inter-action meetings, presenting company information to supervisors, providing an understanding of total concept of supervision, role clarification for supervisors, evaluation and continuous involvement of supervisory and management groups.

The broad steps of the programme are :

(i) Identifying the target group of supervisors which will be involved is the first step. It is necessary that all the supervisors be involved in this programme (from first line supervisors to the departmental head level). This is the reason that this programme is in-company based.

(ii) A seminar for senior management group of one or two days duration is held to explain the significance of this new programme of supervisory development and discuss the role they have to play for the programme as well as for the future. It emphasises the training and development of the supervisors as a duty and responsibility of the line manager, which should emerge from a sound performance appraisal.

(iii) When once the target group is identified it is prescribed that the Chief Executive of the organisation address them in a meeting emphasising the importance of the supervisors and their contribution to the organisation and his concern for the contribution of each supervisor.

(iv) A group of 15 to 20 participants is exposed to a specially designed training experience of one week duration; it aims to provide an understanding of the meeting and significance of work, need for continuously improving the work and the methods by which this may be achieved as well as in dealing with people in achieving the results. In a sense it attempts to fix the role of a supervisor in an organisation in relation to the total economic system.

(v) In the training programme specific time is allotted to deal with the company information to the participants. On the last day a three hour session is held as the inter-action meeting between the participants and the line managers and departmental heads, from which the participants would be attending the programme. In this the participants are made to

think in terms of possible improvements that can be made in their sections or discuss problems confronting them. This enables the line managers to plug deficiencies in the systems and procedures in the organisation. The main objectives of the interaction meetings are :

* To provide a forum for the interaction between supervisors and senior executives;

* To seek clarifications on various aspects relating to company policies, affecting their work;

* To present the problems faced by them in their day-to-day work for wider discussion;

* To present suggestions for improvement in the working of their shops;

* To create, in general, an atmosphere wherein the supervisors would feel the importance of their involvement in the company affairs.

* To evaluate the programmes in terms of case study discussions, case data working and through quiz programmes.

In keeping the spirit of the programme alive on a continuing basis, methods could be devised to get feedback from the supervisors regarding their work as well as their seniors' views on their contributions.

In-Depth Evaluation

Training programmes are now acquiring a prominent place in the activities of an industrial organisation. These training programmes basically serve the purpose both in technological and managerial areas. Each organisation breaks these requirements into specific programmes and organises the same on its own or through the assistance of other organisations in the country. The evaluation of these training programmes is also receiving increasing attention as the cost involved in the training programmes is on the increase and since the organisations intend to know the efficacy of these training programmes, various evaluation procedures are being practised. These include written tests, quiz,

evaluation by the faculty members about the quality of participation and ability in doing class-room exercises and similar factors, and also the reaction of the participants to the training programme itself. Further, based on these reactions and observations, the training programmes are being organised to improve the efficacy. It can also be seen that the methods of imparting the instruction is also undergoing a change, so that the absorption of the programme presented is increased.

In spite of all these, a basic question still remains to be answered. Have we been able to evaluate the training programmes in a complete sense? It is also necessary to ask a fundamental question as to what is expected of the programme? It is well known that the participants who participate in a programme generally get enthused and get additional information in any well organised training programme. But from the organisation's point of view, this is not the ultimate end; until a participant uses his knowledge and skills learnt in these training programmes in his day-to-day work one cannot say that the training programme has been fully effective. So far, the understanding has been that if a person understands and learns a few ideas it would be beneficial to the organisation. Therefore, it is necessary to formulate a clear hypothesis as to what is expected of a training programme; this can be done by specifically saying that this should be reflected on the shopfloor in terms of quality, quantity, costs or ability to deal with people and so on. In this sense, the ultimate benefits of a training programme should be seen in terms of some concrete evidences in physical terms and secondly in terms of changes in attitudes, approaches of participants of a training programme as revealed by his senior in the organisation. Keeping this in view, it would be possible to design an in-depth evaluation scheme, which may be considered as a continuous evaluation over a period of time in terms of the results achieved by the participants as well as evaluation by his supervisor(s).

It is now suggested that an in-depth evaluation of the scheme may be applied to this group of people on a research study basis. This is in addition to the evaluations that are being already made. The new items that may be included are :

(i) The participants may be asked to specifically write down the improvements or any other change that may influence in future, that he has introduced; (say, monthly or quarterly).

In case he has not been able to do so, what does he think are the reasons for the same?

In his view what should be done to create a climate in which he can organise for himself?

(ii) Secondly, once in a quarter, his immediate supervisor and the one next to him may be asked to give their views, regarding the performance of these participants with some details.

Before we apply the above evaluation on a continuous basis, it would be helpful if some form of summary records are maintained as to the status of the production department in terms of quality, quantity, costs, safety, prevailing human relations, etc.

The analysis of this depth survey would provide valuable information regarding positive approach of supervisors and related information regarding problems of implementation of new ideas on the shopfloor.

Further Steps

It should be emphasised that the 'programme' presented above, is the first step in preparing the organisation for stability and growth. It recognises the weakness in the practice of supervision as well as in the infra-structure factors (environment) as observed in Indian industries and other organisations and designs an approach to tackle the same.

The important results from this progamme would be increased efficiency in day-to-day operations relieving the senior management personnel to engage themselves in worthwhile improvements and innovations. Further, the increased interaction of supervisors and managers leads to better planning and implementation thereby increasing the morale of the supervisory group.

After completion of this initial phase, the second step would be to expose the supervisors to specific specialised programmes consistent with their nature of work, e.g., production planning and control, quality control, marketing, financial or personnel aspects and others. These may also stem from the senior manager's evaluation of the supervisor's performance and recommendations thereof.

The third step would be to discuss establishing objectives, measures for the objectives established, evaluation and methods for continuously improving performace; this will be for the organisation as a whole and for divisions and sections. This leads to increased efficiency of sections and divisions leading to better co-ordination amongst the division and achieving results consistent with the objectives of the organisation.

Further steps that may be taken depends on the success of these two steps. The two steps mentioned above takes the organisation to a point of take-off for continuous growth.

However, the steps suggested above, need not be implemented sequentially. They may be dovetailed to suit requirements. The steps only signify the activities to be carried out for achieving total results in terms of stablisation and growth. □

Requisite Changes in Training Methodology and Techniques for Senior Managers

M. M. A. Basha*

Organisation in Transition and Future

Organisations in Government, Business and Industry have been evolved to manage their activities in achievement of their objectives. In all these sectors the process of management involving planning, organising, directing and controlling is basically the same and will continue to be so. What will undergo changes, however, are their objectives and the nature of the structure of the organisation to achieve the new objectives. In the past, the focus of objectives was either to maximise surpluses at the unit level (in the industrial sector) or to enforce adherence to rules and procedures (in the government sector). These objectives are, so to say, inward looking. The anticipated changes in the nature of the objectives will make them encompass larger areas of interest and fields of activity with emphasis on service and economy. Social objectives, ecology, development of the under privileged segments of society etc., are some of the pointers to the changes required. Hence objectives will, in future, take into account people not directly connected with industry but the environment will demand that a higher priority be placed on the quality of service they are providing. We can therefore expect the objectives to be less restrictive than in the past.

The effect of such changes in the nature of objectives will be to make organisations less insular. Where the point and points of contact with the environment were few in the past, they will be many in future. It will no longer be possible to centralise decision making at the higher echelons. In other words, decentralisation, will be inevitable. The ultimate in decentralisation, a vertical decentralisation in terms of authority, and lateral decentralisation in terms of crossing functional and departmental boundaries, will have to emerge.

The job of managers, especially the senior ones, will become more complex. In addition to the coordination they have to generate within, the senior managers will have to cope with problems associated with

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multiple contracts with the environment. This will be particularly so in utility and service-oriented sectors of government and industry in developing countries.

Another indicator of the shape of things to come is given by economists. The primary and secondary sectors (namely, agriculture and industry respectively) predominate in the under-developed or developing countries. A measure of the state of development is indicated by the proportion of resources utilised in the tertiary sector, namely, utilities and services.

Hence there will be a convergence of views as to the tasks and problems of organisation of the future, especially in developing countries, whether we extrapolate the present trends or resort to more classical economic theories. Managers of the future will have to contend with not only domestic but also environmental problems.

Argyris (1964) contends that the effectiveness of an organisation depends on its ability to accomplish three essential aims : to achieve its goals, to maintain itself internally and to adopt to its environment. If an organisation fails to realise these aims it is unhealthy or steadily ineffective. Hence the organisational structure, the relationship within the organisation and the levels of decision making will have to undergo marked changes. We may think of the 'unit' type, the cellular type, the matrix type, the group type or a mix of these as the organisations of the future. There will no longer be the apparently elegance and simple lines of flow of authority that has been witnessed so far. Even the systems approach in organisation will be hard put to display the interweaving enmeshing and overlapping of responsibilities, information flow and decision making.

Managers in Transition and Future

Professional management in India is still in its infancy. We cannot afford the luxury of waiting before going in for industrialisation, until the required number of managers at all levels are developed, even if such a thing was possible. Many of the new entrants at the managerial levels, at present, are exposed to some form of education and training in management. Such facilities were not available till late sixties. Therefore, one finds that most of the senior managers who have two to three

decades of experience in industry and government, were cast in the bureaucratic moulds of a by-gone age and nurtured in an environment of empiricism. In the absence of a formal exposure to the rigours/of management education and lacking a common frame of reference for planning and evaluating their decisions they were hard put to prove their mettle against their more formally educated juniors.

While the junior and the middle management levels have, by and large, equipped themselves with concepts, techniques and tools of management, these were denied to senior managers. Thus, there is a generation gap between the senior managers and fresh entrants in more senses than one. They are the link with the pre-professional management era.

It is these senior managers whom one is thinking of training and developing so as to face still newer challenges. In a larger prespective, the present class of senior managers may be the least important historically, easily expendable and in any case likely to fade away soon. But presently, they have a very important responsibility to change and effectuate change. Their dilemma is : should they change and be instruments of change for the larger interests and thereby risk expending themselves earlier because of inherent inadequacies, or, play out their roles on familiar grounds and fade away into oblivion ?

When considering the changes in training methodology and techniques for senior managers, one should have their total profile. However, what emerges is not too edifying. They are the persons who have been rocked by changes in social values and systems and are a link with pre-independence era. They were not nurtured in their infancy for the onerous complexities of management, but are now faced with the responsibility of transforming the profiles of middle and junior managers while not fully acclimatising to their own tasks. Thus, they are continuously caught in the dilemma of whether to do or not to do and suffer the attendant ego complexes. The author is of the view that this is the emergent profile of the senior managers.

Changes Required in Senior Managers

Qualitatively, one can spell out some important attributes required of senior managers of the future. They are personal Qualities, Knowledge, and Skills.

Personal Qualities :

—Flexibility,

—Quick Response, and

—Consistency.

Knowledge (Cognitive domain) :

—Specialisation and Versatility,

—Systems and Techniques, and

—Behavioural Sciences.

Skills (Affective domain) :

—Interpersonal and Team Building,

—Forecast and Manage Environment, and

—Initiate and Facilitate Systems.

Senior managers should develop the above attributes in order to

* appreciate changes in environment and their own tasks,
* be effective in initiating and managing changes train subordinates adequately, and
* act as inter-system facilitators.

Factors Affecting Training of Senior Managers : Time Factor

The training of senior managers presents a paradox. While the transformation to be brought about is of considerable magnitude, there is a paucity of time. Since changes in senior managers is a pre-requisite to changes at other levels, it calls for an intensive training.

Other factors which are equally important are :

* Motivation considering their experience, attitudes and complexes,
* Problems of assimilation at their age, and
* Unfreezing and freezing.

These have to be borne in mind while considering the strategies, methodology and techniques for training senior managers.

Strategies and Approaches

Education and training have always tended to depend more on contrivance than on design, and for this reason, art and craftsmanship have been rightly emphasised in the training process. However, times have changed, and a more systematic approach is necessary. In the past, ideas always lived longer than people, but, today people live longer than most ideas. As De Bono (1969) has pointed out, technology has so speeded up things that ideas may have to be changed within a generation instead of between generations. Yet, our culture and education have always been concerned with establishing ideas and not with changing them. We are living, in fact, in an age of instability or discontinuity, when skills based on mechanisation are gradually being replaced by skills based on information and knowledge technology. In order to prepare for this new role, education and training require a new conceptual framework against which decisions involving change and innovation can be made.

In evolving a systematic approach to the training of senior managers, we have to consider

* the profile of an average senior manager,
* the variability of individual manager at the extremes of the scale,
* the organisational environment (culture).

The choice of a training strategy would depend on the broad approaches available and selection of the one most suited to our generation of senior managers. The classical approach involves an autocratic system which is teacher dominated with emphasis on subjects, product orientation extrinsic manipulation, class teaching, fixed stimulus and inculcating fixed responses, convergent thinking, competition and inwardly directed attitudes.

An intermediate approach could be a *laissez-faire* system which is permissive with emphasis on methods, processes, random reinforcement, group teaching, multiple stimuli giving rise to varied responses,

convergent thinking but with free expression, co-operation (random) and outward looking attitudes.

A third approach is a democratic system which is enquiry-centred, with emphasis on discipline (rather than subject/method), performance, independent study leading to response mastery, convergent and divergent thinking, innovation and self-actualisation.

If the proposition stated in the preview that senior managers should be agents of change is correct and that they should inculcate democratic methods, with emphasis on discipline, performance and enquiry in their juniors leading to response, mastery, better decision making and self-actualisation, the choice of the last stated system would be a foregone conclusion. However, because of the particular culture of the organisation, from which senior managers are drawn, attitudes of individual managers and their motivation would sometimes demand resort to one of the other two systems in the early stages of training. This has a bearing on the selection of participants so that homogenous groups could be formed in order to administer a system or combinations progressively.

Since time is an important factor, one cannot change all attributes in senior managers to the desired levels at the same time; one will have to prioritise the attributes. For example, one has to decide what attributes one would like to concentrate on.

Methodology

We recognise three distinct stages in the training process—selection, inputs and follow-up. While the preceding thoughts serve as a backdrop, it is worthwhile to discuss in some detail the methodologies involved in selection and during the input stages. Since the ultimate aim of all training and development is the effective transfer of knowledge and skills to one's job in a desired manner, the follow-up stage is important, both, to facilitate the process of application as well as to evaluate the results and efficiency of the system.

SELECTION

Development could be approached from two view-points : individual-orien-

ted (the career development approach) or the broad organisational-analysis approach.

The objective is to ensure that senior managers recognise and identify changes required in the organisation (due to changes in objectives and environment) and facilitate transition at lower levels. Is there a critical trainee mass for such training which will produce perceptible changes at the organisational level? Or should it be on some selective basis irrespective of 'mass'? If it is the former, is it better to train all senior managers and if it is the latter, what could be the criteria for selection?

At the planning stage, a number of decisions will have to be taken on how the development should be scheduled for a given number of senior managers. It could be in intermittent batches with cautious evaluation at every step or it could be in 'cascade' with evaluation being used for the limited purpose of modifying the 'inputs' methodology and techniques.

INPUTS

The inputs for any training methodology would on the objectives of training such as behavioural changes sought to be brought about, the area of operation or specialisation, reinforcement of the cognitive domain and finally the realisation of these inputs in the affective domain (these are dealt with in same detail in the discussion of techniques).

From among these objectives one has to be clear as to which is the most important and therefore, to be given emphasis irrespective of the methodology. The restriction imposed by the time element has already been referred to earlier in the consideration of strategies. Problems that can be posed are, how much emphasis is to be placed on behavioural aspects compared to cognitive aspects ? What will be the emphasis on 'affective' aspects and purely psychomertic skills ?

Once these questions are answered and the limitations known, one can have a better appreciation for selection of particular methodologies and their mix.

The methodologies available are :

Off-the-job training :

—Self-development

—Formal programmes

—Project work

—Combinations of the above

On-the-job training :

—Apprenticeship and under-study

—Job rotation

—Performance appraisal and counselling

—Combination of the above

—Off-the-job training followed by on-the-job training.

When considering methodologies one should consider both, resources and time. Is on-the-job training really feasible considering the resources? If it is, who will guide, appraise and counsel the seniors? Will this effort be available internally or has to be obtained from outside? Can the training be programmed within the given time-frame? Depending on what broad methods are chosen, what should be the mix and proportion of the particular methodologies?

FOLLOW-UP

Once the desired methodologies are framed, one would be clear regarding the assessment of their effectiveness, the procedures for assessment, the periods of intervals when the assessment is to be carried out. The exact measures adopted to assess the extent to which the various objectives have been achieved etc., have to be visualised and spelt out. In order to find the extent to which the training has improved the senior manager's knowledge, skills application, ability performance etc., these have to be measured prior to training so that improvements effected could be assessed for purposes of record and evaluation of the training as a whole.

Techniques

All types of learning could be classified under the following three groups :

* Cognitive or those concerned with information and knowledge;
* Affective concerned with attitudes (AFFECTIVE) values, responses, etc.
* Psychomotor skills involving muscular and motor skills or manipulations.

In a training or development situation, one is concerned with transferring the knowledge and skills in the above three areas to the trainees. This transference could be termed 'acquirement' phase of the skills and knowledge. But the really important phase is the 'accomplishment' phase wherein the trainee can relate the knowledge and skills to their work situation. The final phase is that of 'performance'. Hence, the phase of learning could be grouped under the following heads :

* Acquirement phase;
* Accomplishment phase;
* Performance phase.

TASKS AND TASK ELEMENTS

All task elements to be performed in industry can be broadly classified as under :

* Signal task elements which are the simplest and whose need is obvious;
* Procedural task elements requiring the carrying out of certain actions in a given order;
* Simple discriminatory task elements involving recognition of essential differences and similarities;
* Complex discriminatory task elements;
* Diagnostic or problem solving task elements involving detection, isolation, identification or correction of faults.

Analysis of tasks by the constituent elements is necessary so that knowledge, skill and attitudes are identified and isolated, with a view to ultimately synthesising them into hierarchical organisation of tasks

and task elements. This will enable to choose the desired training methodologies and techniques suitable for task performance.

COMMUNICATION

The communication media available for presenting complex rules and procedures are :

Strategy	*Accuracy*
Continuous Prose	Low
Hueristics	Low/Medium
Algorithms	High
Decision Tables	High

Each of these media have their advantages and disadvantages. For low level tasks, algorithms and decision tables should suffice. For complex discriminatory and diagnostic tasks, prose and hueristic methods would be inescapable. Hence the presentation and techniques selected should emerge from such analysis.

TEACHING OF THEORY

Theories are grouped into two classes viz., 'Realm' theories and 'Domain' theories. 'Realm' theories are essential to the subject matter and have to be remembered. 'Domain' theories are of a higher order and are helpful or pre-requisites to learning.

These take the form of such useful teaching devices such as analogies, models or paradigms.

Problems of Training 'Older' Trainees

Older people are generally less flexible in their attitudes. Rapid changes and innovation destroy the stability of older trainees and hence their

confidence in changing technology, values and organisations. This leads to motivational problems, problems of unlearning and forgetting, resistance to change and adjustment problems. The techniques to be selected should be optimal to cater to training of older groups to which our senior managers belong. It has been observed that older people learn more by synthesis, evaluations and by independent study.

Objectives and Selection of Techniques

The selection of a particular technique or a blend of techniques should have the merit of achieving the training objectives in the shortest possible time, and if possible, at a minimum cost. The factors which will govern the selection of techniques will be :

* The type of learning required in each topic/subject/area;
* The 'phase' of input (viz., acquirement, achievement and performance);
* Optimal communication media (viz., prose, hueristics, etc.);
* Essential theory to be taught;
* Problems of 'older' trainees.

Characteristics of Training Techniques

Lecture : Traditional, autocratic; high density; suitable for concepts and complex rational presentations; greater immediate recall and longer retention; participant-passive; unsuitable for attitude changes, leadership and problem solving sessions; good for higher order cognitive instruction but not suited for 'affective' instruction.

Lecture Demonstration : Lecture demonstration is good for technical and industrial training. It is less autocratic than lectures but less permissive than discussions. It is also good for average and below average participants with mediocre faculty.

Group Discussions : Participant centred; structured or unstructured—better for diagnostic or problem solving situations; rapid learning;

higher accomplishment and performance; more commitment from participative type of trainees; not beneficial to superior students; time consuming; inhibited in presence of outsiders.

Case studies : Suitable for effective objectives and real attitudinal changes and higher order cognitive objectives; (poor for lower order cognitive) most suited for highly diagnostic behavioural problems; time consuming for introducing concepts and principles.

Role Playing : Same as case studies with higher associative retention-experiential to those taking part—unsuited to introvert participants—good for rehearsing cognitive skills.

Games : Specialised forms of role playing; specially applicable to more complex cognitive and inter-related skills; engender decision making-stimulates real life better structured than role play and more objective; costly to develop and administer.

Independent Study and Project Work : Performance oriented—good for studying, highlighting and solving individual and group problems—effects greater openness, receptivity and tolerance of difference; better operational skill in interpersonal relationship—could be highly effective in affective skills—sometimes considered a risk.

Incident Method : A Combination of Case Study and Role Playing

Conclusion

Techniques are media for transference of skills. The contents would depend on the context of the programme, time available, depth, priority given to types of skills and phases of learning and communication media. Appropriate techniques should be selected for each of the subjects/sessions so as to achieve the objectives in minimum time with maximum economy.

There are many combinations and possible alternatives available for every programme for senior managers, but it is hoped that optimal training strategies, methodologies and techniques for generic types of programmes would be evolved in due course. □

Role of Management Development

Jagjit Singh*

The art of management development has received much attention only in the last two decades or so. In India, even at present, there are only a few enterprises practising systematic management development as a part of company policy, based on detailed analysis of company needs and individual needs in the overall organisational setting. However, a healthy sign is witnessed when progressive companies have started realising the need for a programme for management development as part of normal company policy and practice in the running of a business, as a method of ensuring the best possible use of management manpower.

Broadly speaking, a Management Development Programme may be defined as a systematic approach of combining improved present performance with planned anticipation of future needs for management manpower. The emphasis is on *systematic*, which is more appropriate to such programmes in the present state of human knowledge than *scientific*, which seems to carry a connotation of a greater degree of accuracy and measurement than has yet been achieved.

Need for Management Development

Management development is not new; it has been going on from time immemorial whenever men have come together in organisations — be it military, governmental or industrial. But there is a marked difference in today's approach than hitherto adopted. The growing complexity of operations and the deepening knowledge of human motivation, whether in individuals or in groups, has led to focus attention on the method of making the best use of management resources, which is becoming an increasingly scarce commodity.

The problem is a complex one which is unique to every individual and every company, for it is made up of an infinite number of variables in a state of continuous change. Hence, there can be no ready-made

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solution designed to fit all cases; each case must have its own Management Development Programme, tailor-made to suit its own situation in respect of time, people, location and total environment. Each programme must be dynamic, flexible enough to take account of rapidly changing situations, yet with operational guidelines adequate to guarantee maximum continuity of general policies for survival and growth of the organisation.

Responsibility for Management Development

In India, the responsibility for Management Development is generally associated with the enterprises. It is the enterprise that nominates one to various training programmes in the country and overseas. It is the enterprise/firm that receives literature on various training programmes. Workers, supervisors and managers are sent to training programmes for one or more of the following reasons :

* To provide a vacation to an otherwise busy executive;
* To punish the 'guy' because he does not toe the line;
* To investigate and evaluate his department in his absence;
* To provide an opportunity to meet other senior executives and thus create prospects for increasing bigger and better customers;
* To continue to enjoy the best image possible by sending participants to all the training programmes;
* To provide participants or faculty members to make an impression on participants that the company is the best in industry and thus has a spillover for improvement in goodwill and better sales.

The foregoing shows that the approach used needs to be rationalised and compared with the overall objectives of the enterprise.

It may be stated, however, that responsibility for Management Development does rest only with the enterprise. It rests equally with every supervisor and the individual himself. Walter Wikstrom in his book

"Developing Managerial Competence" has summarised the area of Management Development as follows :

"All development is self development;
Activities should be tailored to the man;
Development requires action;
Controls can aid development;
The company 'climate' is important;
The boss has a major influence;
Development is a line responsibility;
Development is a long-range process."

Modern Management Development Programmes recognise the key importance of the boss, the company climate, the variation in individual needs and capacity, and the value of training, seminars and coaching for all managers operating the programmes. Above all, they emphasise 'on-the-job training' in the work situation. That is where managers will learn most. But the company Management Development Programme will also provide internal and external courses to supplement and augment 'on-the-job training'.

Proposed Management Development Plan—A Specimen

A. Introduction

A Company Management Development Policy
Detailed Objectives of the Plan
"Man-Based" and "Job-Based"
Basic Objectives, Company Expects the Plan to Attain
Conferences and Training Seminars
A Systematic Plan—developed after experience in operating it.

B. The Method—Management Appraisal

Performance Appraisal
Management Appraisal Meeting
Performance Revenue and Target-Setting Interview
Management Appraisal Summary
Built-in Follow-up Procedure

C. The Method—Management Succession and Management Manpower Planning

Are the right men in the right jobs ?
Are they performing to their maximum capacity ?
Are there short-term and long-term successors available ?
What action is needed to guarantee satisfactory management succession ?

D. General Comments on Your Company M. D. Plan

Relationship between Management Development and Management by Objectives

The special achievement of MBO has been to integrate management development with the company profit improvement plan by increased emphasis on results in key areas. Companies had already made some headway in this direction during the evolution of their management development programmes as these adjusted themselves more closely to company needs, experience and personnel. MBO used by management development programmes primarily in the context of organisational needs, is the kind of perspective in which individual managers must see their own performance and development. There is also a change of emphasis from the individual to the organisation, but the lesson of the key significance of the individual has been well and truly learned and is effectively utilised in all good MBO plans.

There are now a few progressive companies in the West who are not operating MBO or at least incorporating some of its principles into their operations. MBO as an approach has now succeeded Peter Drucker and others' 'results-oriented' approach. Even the Japanese have realised that the most important prerequisite for 'Management by Objectives' is a clear perspective of the business climate on the part of top managers. □

Design and Development of Training Programmes

Charles Norman*

Introduction

The organisation should have an overall picture of its training needs and also an understanding of the specific training needs for different levels of staff. These clear definitions of needs would suggest clear training objectives.

Objectives

The objectives specify what a trainee must be able to perform at the end of the training. This is comparatively easy in those cases where the training is concerned with knowledge or skills, but it is otherwise where it is concerned with attitudes.

In writting the objectives, the words and statements used should be concerned with what the trainee would learn by the programme and not what inputs the training will provide. For example, statements like 'To give trainees an acquaintance of.....', 'To convince trainees about.....' or 'To explain the advantages of.....', etc., speak of what the training will do and not what the trainee will learn.

Often in establishing objectives, the participants are consulted. A mere knowledge of the background of the trainee group can help only partially; on the other hand, a discussion with the group on its expectations of the programme or a precourse evaluation which provides a more tangible picture of the level of knowledge or skills the trainees already possess will facilitate establishing the objectives closer to the real needs.

Strategy

The first step in programme design is to select a strategy to meet with the objective. For example, if the objective is to help gain an understand-

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ing of the 'General Management Functions' at a certain level, it would suggest 'organisation development' strategy focussing on job content and organisational processes. Similarly, an objective to help gain skill in 'independent staff management' would suggest 'Personnel Growth Laboratory' strategy and so on.

Component Objectives

The second step is to break the general training objectives into constituent parts of knowledge, understanding and skill. For example, 'Understanding General Management Functions is heaviest on knowledge and understanding and lightest on skill. On the other hand, 'Better Staff Management' is heaviest on skill and lightest on understanding and knowledge.

Content

Once the objective of the course has been decided on, its content will follow naturally. A precise statement of the objective will go a long way towards deciding what is relevant and rejecting what is unnecessary. The criterion is that the subject or the topic should be essential for the attainment of the knowledge, skill or attitudes required for the performance of the job to the standards aimed at. The course designer should set precise objectives for each of the various subjects or topics to be included so that he knows exactly what he hopes to achieve.

Methods

The next task is to match these components with appropriate training methods; to estimate the number of sessions and events; and to clarify for each event, the particular part of the objective it is to meet. It may be difficult to estimate how many practices may have to be scheduled in order to ensure a given level of proficiency for trainees. For example, the objective 'understanding general management function' may be attempted by a few case studies, some focussing on problems in different functional areas and others on problems of coordinating different functions. On the other hand, the objective of 'enhancing skills in staff management' may require a 'laboratory' method and a few cases focussed on different staff problems. The designer has a vital interest in seeking a balance among the various methods. Too many lectures in succession, for

example, with too little active work by the trainees may cause them to lose interest. Case studies, projects or visits would be more relevant if brought in at appropriate times to give the right emphasis to particular aspects.

Thus each event (session) would be made up of the following data :

* General and specific objectives
* Content
* Training method
* Time
* Evaluation methods
* Review time, and
* Person(s) responsible for the events.

Duration

The next step is to arrive at the total time, considering the content and specifications of the different training methods proposed to be employed. The duration of the programme has a bearing on costs. So, it often becomes necessary to critically examine the various subjects or topics with a sense of priority and categorise them in terms of which are 'essential', and which are just 'desirable'. This analysis of what the trainees 'should' know *vis-a-vis* what they 'could' know, keeping in focus the objectives, will facilitate settling on an optimum duration for the course.

Time Table

The next step is to decide on the packages in which the programme could be offered whether full-time or part-time; whether residential or non-residential; number of days and number of sessions etc. For example, a full-time residental programme could be ideal for laboratory training since it offers isolation and intensity of training. The greater the attitudinal component, the more important becomes the intensity of training experience. An alternative package would be full-time but non-residential. This programme could be close to the work and residence of participants. This would involve participants returning every evening to family and friends which means lack of undivided attention on the programme,

making the training less intensive. This package may not affect training that aims at increased knowledge and information; but does affect training that aims at increased knowledge and information and at new attitudes and human relations skills. The advantage, however, is its reduced cost. A third alternative can be full-time training for laboratory training followed by one session a day during or after working hours. The programme will get stretched depending on the number of sessions planned per week. Finally, the package may consist of daily sessions during or after working hours. This is the cheapest and useful design for reaching training objective that requires frequent contact with jobs in the work setting. The participant's attention would be divided. There will be loss of time as participants change gear everyday from operating to training and have to warm up for each session. Other packages possible are full-time weekend programmes with part-time in between.

Sequence

The chosen subjects must be arranged in the right order or sequence for presentation to the trainees. This may be either the *psychological order*, i.e., the order which is easiest for learning; or the *job performance* order, i.e., the different parts of a job carried out; or the *logical* order imposed by the nature of the subject itself. Sometimes these coincide or else the psychological order may prove best for presenting the course material to the trainees. It will be useful for the designer to keep in mind the process of effective learning which is to move from the "known to the unknown", from the "concrete to the abstract" and from the "simple to the complex", etc. In programmes concerned with attitudinal change or development, a laboratory method is often resorted to wherein the sequence begins with "unfreezing".

Sequence Relating to the Learning Process : The Learning Process consists of (i) Unfreezing, (ii) Moving, and (iii) Refreezing. Unfreezing is the 'questioning of' established or known ways of looking at situations and this must take place in the early part of the programme. Without unfreezing, participants do not attach enough importance to the problem to wish for new behaviour and thereby to learn. The early part of the programme must offer stimulation and involvement, e.g., laboratory, stimulation. Through these, participants get challenged, churned up and motivated to deal with the consequent dissonances, inadequacies, etc.

Unfreezing in training is what is ploughing in agriculture. This is followed by seeding and planting : exploration, new knowledge, experimentation and such events that cause learning. Study of cases, practising new techniques are a few examples. Refreezing is the stage of fitting in the new knowledge, understanding and skill learnt in the training situation into personal and organisational day-to-day work and living. Churning up at this stage is inappropriate. What is needed is consolidation. Individual assignment and reflection will be helpful.

Sequence Relating to Prevailing Expectations : At the beginning, both participants and trainees have expectations of each other and also of the training programme. If these expectations are mutually shared, uncertain and anxious feeling will be reduced, enabling the group to move freely. An inaugural speech can be a good starting point. This is often followed by an 'expectation sharing' session by participants. These events are so set up as to facilitate participants and trainers talk together and get to know each other informally. These help the participants to get rid of their day to day preoccupations and to orient them towards the training programme. Likewise, when the programme draws to a close, the participants will be concerned with work and home situations which they have to face mostly alone. Problem-solving, case discussions, goal-setting etc., will be appropriate events for this back-home stage of the programme.

Reflection

Reflection is essential to convert training events into personal experiences, that is, into learning. Time should, therefore, be allocated for reflection. It may be titled as 'private study' or 'alone time'. If reflective time is not planned, the days may be filled up tight with activity and participants will return to their job wondering what the major events of the training were all about. If the programme is long, participants may also 'tune out' of training events from time to time to satisfy their need for reflection. Then they will be physically present but mentally and emotionally busy elsewhere. The ideal would be to provide adequate new data for stimulation and then provide opportunity for reflection.

Personal Involvement

There can be no learning without personal involvement. The starting events should be personal experiences that acquire intense meaning to

the individual. But then these are to be followed by analytical and conceptual understanding of the experience for future action. The former is stimulating personal involvement and disturbing; the latter is a clam, 'looking back' on what happened, listening to one another's experiences and understanding. The ideal syllabus would move participants towards intense invovement and then backtrack for clarification and understanding.

Practice

No skill is acquired without practice. Practice throws up new questions to learn from. Most training designs are based on the concept of 'First theory, then practice', as if practice is 'applied' theory. But early practice facilitates understanding of theory and raising of questions about theory. A participant at practice is frequently heard to say, "Oh ! Now I understand". In the case of 'early' theory, the participant may not adequately understand and often will not be able to check back when practices come later in the programme. On the other hand, continuous practice tends to become mechanical. The ideal syllabus would provide practice opportunities until improvement in performance tapered off short of the training objective and then provide opportunities to think and talk about what skill presented problems and so prepare for the next practice.

Individual and Group Events

Participants provide stimulation to one another through their different experiences and ideas. They also provide an individual with opportunities to test and check his ideas and his effectiveness as he takes on new directions of learning. This kind of testing followed by confirmation enables committing oneself to change. In a group setting, learning takes place at a pace that can be kept up by most participants. Individual learning is thereby hampered in quality. The syllabus should, therefore, provide for both individual and group tasks. Certain objectives are best attained through group activities, e.g., setting goals, planning action, diagonising problems, learning social skills, etc.

There are other objectives best achieved by individual work activities. Examples are skill development, collecting and organising information relevant to a task, etc. In individual learning, a participant can take