Problems of Management Consultancy Development in Developing Countries : An Overview

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Introduction

Problems of management consultancy work and running of consultancy organisation are varied and diversified. Therefore, it is hard to generalise these problems irrespective of different backgrounds, conditions and environments. However, as given in the survey report, predominant problems of management consultancy services in APO member countries can be summarised into the following areas :

(a) What are the suitable policies and directions in developing consultancy activities in a country under a given condition of economic and industrial development, and the prevailing problems of business enterprises and consulting organisations?

The question has direct connection with the presumption that there would be certain groups of consulting patterns best suited for different countries having different stages of economic/industrial development. It is quite likely that problems of business enterprises as well as consultancy organisations are highly interrelated with different development stages.

(b) How to secure consulting assignments?

This is one of the most crucial problems faced by most of the consulting organisations in developing countries. Problems can be classified into the following :

(i) How to let businessmen aware of the existence of consulting facilities and availability of consultancy services.

(ii) How to let businessmen understand the usefulness of consultancy services.

(iii) How to obtain sufficient amount of consulting assignments needed for maintaining existing consulting staff.

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(c) How to manage management consulting organisation?

Perhaps managing the management consulting organisation is one of the toughest jobs among other business ventures. Major problems would be as follows :

1. How to decrease relatively high rate of personnel turnover.
2. How to promote prestige and social standing of consultants.
3. How to eliminate unethical consultants without violating human rights and freedom of profession.
4. What would be the suitable remuneration system for consultants.
5. How to control activities and work assignments of consultants.
6. How to evaluate performance and achievement of consultants.

(d) What are the best ways in recruitment, training and development of consultants?

Aptitude of consultant is still not clearly defined. It is still a controversial issue whether consultants be recruited from college graduates or from experienced specialists. Method of on-the-job training is not developed fully and there is no generally-accepted concept and approach. Most of the training programmes are nothing but management development/training programmes without containing curricula for professional practices and skills.

Scope and Contents of Consultancy Services

(a) The job of a consultant can be summarised as follows :

Consultancy Services
- Diagnosis
  - (1) To clarify the business problems
  - (2) To design effective course of actions for solving problems
- Assistance in Implementation
  - (3) Orientation and training of people for successful implementation
  - (4) Practical guidance and assistance in implementation as well as follow-up

(b) In reality, scope of activities carried out by different types of consultants is varied.

	Defining problems	Designing systems for solving problems	Orientation and training	Guidance in implementation
Diagnostician	A	B	C	C
General Consultant	A	A	B	B
Specialised Consultant	B	A	B	A
Trainers/ Instructors	C	C	A	C

A = Major area; B = Mostly being covered; C = Usually neglected or ignored

In public sector, where consultancy services are carried out in connection with small business/industries development programme the scope of activities is, by and large, limited to diagnostic work. Such a service is normally extended "free of charge" in conjunction with several assistant schemes.

Complete consultancy services covering all the areas mentioned above are usually carried out by professional, private consultants on a "cost plus basis".

Ironically enough, it is observed that, irrespective of the stage of industrial development of a country, requests from clients call for an emphasis on practical guidance on implementation without due regard to the diagnostic process. Small businesses in developing countries are somewhat reluctant to disclose business secrets to the outsider including consultant for one reason or another. And yet, they seek outside help for solving specific problems. According to their understanding, consultants are contracted specialists who would undertake specific problems which they could not handle themselves.

There are various institutions undertaking management training and development programmes. Officers assigned to these institutions as instructors or trainers often take advantage of being called as management consultants even though they rarely undertake diagnosis and/or implementation as vices.

(c) Areas where consultancy services are rendered can be classified in accordance with the scale of business.

Large enterprises are usually covered by private, professional consultants including foreign firms and this area is usually omitted in discussion of consultancy services in developing countries.

Small and medium industries are the target of consultancy services in developing countries. Considerable difference exists among them with regard to policies and guidelines leading to the selection of clients.

(d) There are also different views as to whether consultancy (or more strictly diagnostic) services should cover individual assignments, group work or mass media instructions.

While individual method aims at extending consultancy service to each

Type→ Approach ↓	Consulting	Training
Individual	Diagnosis, advisory, and/or consultancy services to individual or model plant	Demonstration (pilot or model plant) services for in-plant training
Group	Diagnostic, advisory and/or consultancy service as Trader-wide, District-wide, Shopping centre, Commercial block, Industrial estate, etc.	Group Training, Itinerant team, Marketing clinic, Training course, Seminars, Discussion groups
Mass	Meetings	Exhibition, Meetings, Radios, Televisions, Publications

individual client separately, group method applies consultancy services to a group of business enterprises of the same trade, industry or those located at a certain area such as an industrial estate, industrial park, industrial apartment, etc.

There is a need for selecting proper scope and content of consultancy services in different countries from a strategic viewpoint while giving due regard to different prevailing conditions.

Problems on Promotional Activities

It is a common problem of almost all the consulting organisations that businessmen usually are not aware of the existence or availability of consultancy services. Even if the availability is known, they are rather skeptical about the usefulness of such consultancy services.

Reasons for employing consultancy services often illustrated by management consultants are as follows :

(a) *Expertise :*

Clients can best utilise knowledge, skills and experience of consultants which would not otherwise be available to these business enterprises.

(b) *Financial :*

Clients can utilise the services for a limited duration, thereby avoiding constant financial and administrative burden in maintaining extra specialists.

(c) *Psychological :*

Clients can take advantage of a relatively favourable reaction on the part of employees in responding to outside advice than to orders/ instructions from within the organisation.

All the same, many potential clients are reluctant to employ external consultants for one reason or another, as given further :

(a) If the service is not free of charge, small businessmen often make excuse that they cannot afford to pay the fee.

(b) If the service is free of charge then they are apt to say that they are not sure of the benefit of the service. Further, they often say that 'free' means 'useless' as both parties do not take responsibility for the outcome.

(c) Apart from the expenses involved, many businessmen are concerned about the utility of such external advice.

Thus, in spite of the efforts by the consultants in advocating the usefulness of their services, businessmen remain cautious and skeptical. Perhaps the most important aspect of promotional activities is to sell the benefit of consultancy service to the future client by adopting the following measures :

(i) *Publicity :*

The concerned organisation should make available the name of consulting firms and particulars of the consultants working with them as well as the procedure for acquiring their services. The accent on publicity may be through case presentations mainly for demonstration purposes.

(ii) *Model Shops :*

Concentrated consultancy service is made to a selected business enterprise so that the achievement could be made public as a successful case. In reality such successful cases are unfortunately very few and far between. However, most of the small businessmen, especially in the earlier stage of industrial and management consultancy development, often seek one or several of the following benefits as by-products of the consultancy service.

(a) *Linkage with Financial Assistance :*

To seek financial assistance, especially of long-term cheaper loans, after having received diagnosis from consultant of an authoritative body

whose report definitely becomes an evidence to justify the extension of financial assistance.

(b) *Linkage with Technical Assistance :*

To seek technical assistance, including financial assistance, necessary for purchasing or renting new machinery or equipment in line with the recommendation made by consultant. They expect that the consultant will prepare a report to justify the new investment, thereby being able to have an access to financial resources with supporting documents.

(c) *Linkage with Sales/Marketing Assistance :*

In expectation that the institution which has rendered consultancy service might extend help in providing or exploring sales and marketing opportunities.

Even in the case of medium/large scale industries they often find indirect merit in the acquisition of better financial resources or marketing opportunities after receiving consultancy service. They believe that the employment of consultancy services could be an endorsement of a healthy business management leading to better image and standing in the business community.

Irrespective of the political system prevailing in a country, invariably there is an obligation on the part of the government, to enforce administrative guidance upon small business management in relation to industrial/small business development programme. While the business enterprises have to comply with the guidance laid down by the government, they, in return, enjoy some privileges or benefits such as financial/technical assistances, tax holidays, etc., accordingly :

(a) Consultancy services for small businesses, which sometimes call for diagnostic service, extension service, management guidance, and the like, may advantageously be linked with financial, technical and/or marketing assistance schemes at the earliest stage of consultancy development, though this is not an absolute necessity.

(b) Consultancy service for small enterprises is usually carried out by governmental or public institutions connected with regional or industrial

development programme. In this aspect, these services consequently, whether it is so intended or not, tend to relate with administrative guidance or control by the government. This draws obligations on the part of businessmen to receive consultancy services provided they could anticipate accrual of commensurate benefit from this relationship.

Another problem is promotional activities in the interaction among professional ethics and business affairs. Since a management consultant is considered to be a professional one, establishment and enforcement of professional ethics is considered to be a vital issue. Their activities are greatly restricted by being forced to comply with the code of ethics and/or ethical standards generally accepted by the profession.

General practice in this profession within the scope of professional activities is :

(a) Do not advertise oneself in a *self-glorifying* and *exaggerated* manager.

(b) Also the profession, because of its objectivity, sincereity and integrity, calls for a basic attitude among consultants not to promise any substantial results (benefits) prior to the initiation of the service. It is based on the belief that the authority and responsibility of managing a business are on the shoulders of managers and not on the consultants.

Such an understanding will also influence the design of promotional campaign by consultants utilising appropriate publications. To what extent they can sell themselves about the real benefit of consultancy service by demonstrating real cases and by presenting actual figures is a matter of balance between business promotion and ethics.

Though, from strict ethical considerations, the consultancy organisations should not use advertisement as a media for direct promotional activities, they may still advertise for recruitment of consultants for their own organisation, thereby providing an indirect but effective promotional measure. Moreover, the consultants themselves may use other indirect means and media such as books, articles in journals and newspapers to propagate their activity. They may also use the radio and T.V. media to conduct seminars and lectures or give speeches. The basic approach

should be to make the public aware of the availability of such capable, highly-experienced consultancy organisations.

Stage of Development in Promotional Campaign

Render consultancy service with either legal enforcement or by providing financial/technical or marketing assistance → To extend special efforts in arriving at substantial result at a selected company

——model plant —→ To publicise the usefulness by illustrating the case of model plant

Gradually to switch the promotional activities by consultants.

Administrative Problems

Perhaps the most critical issue with regard to personnel management in consulting organisation is the relatively-high ratio of personnel turn-over, perhaps caused by inadequate compensation system and improper treatment of consultant within the organisation including opportunity for promotion.

Another aspect is the administrative control of the performance of consultants by regulating the number of working days and providing a basis for the consultancy fee and evaluating the consultants in relation to the prevailing wage scale.

It is generally observed that the main reason for consultants not staying long enough in any organisation is that the salary offered by outside firms is more attractive.

Further they do not believe that their status within the organisation, as specialised staff, is necessarily as high as they had expected or in comparison to other administrative staff. It is a general practice in governmental organisations that a generalist has a better access to higher ranks than a specialist.

Compensation (remuneration) system is another controversial issue. While in other positions, salaries are determined by indirect, potential values such as educational background, years of service and age, the consultants prefer to receive remuneration commensurate with their achievement rather than their background. This dichotomy often leads to problems in wage administration.

Organisations often face with the problem of part-time jobs including lecturing, advisory service, writing, broadcasting etc. by consultants. Hence, it is imperative to set up detailed rules and regulations applicable to them.

Policies in this regard do vary from one organisation to another. Some organisations are very strict by treating almost all these part-time jobs as official ones and insist that income so accrued belong to the organisation while others are more lenient. The latter view such services as a form of incentive for consultants for self-development.

Workload assignment is another difficult task for the consultancy organisation. Further, since consultants are engaged in outside activities, control of their activities is as difficult as in the case of salesman or service engineer. If this includes performance control, the task becomes even more complex. Management consultancy, being a profession, requires that more control of hours or days spent, or comparison of actual and predetermined schedule, would not be sufficient. Perhaps the best way to arrive at a performance control would be to get information on reactions from the clients. How to formalise this system is another controversial issue.

It is a perennial problem on a nation-wide basis to eliminate unethical consultants. Some believe in establishing authorised titles for consultants which are given only after a strict examination to the experienced consultants. Others are of the opinion that it is only a client and not the government authorities or even senior consultants who can evaluate whether a consultant is a capable one or not.

Training and Development of Consultants

There are basic areas to be discussed before getting into technical aspects of training and development of consultants.

(i) *Determination of the aptitude of a potential consultant* : This will influence the recruitment policy as well as the screening criteria for applicants. It is still a controversial issue whether preference should be given to a college graduate or to those who have some amount of professional experience.

There is really no consensus as to whether a consultant should be a generalist or a specialist.

(ii) *Requirements for consultant* : Unfortunately, this aspect has not so far received sufficient attention to enable formulation of a proper curriculum and syllabus. More often than not, they receive a cursory treatment within the broad framework of management training and development. The basic deficiency is due to the fact that more knowledge and know-how of management is not sufficient for management consultants to carry out their business. They need special professional skills such as interviewing, recording, report preparation and presentation, training, overcoming resistance etc. Furthermore, consultant's job is to sell his idea and persuade company personnel to implement the recommendation by their own initiative. This requires special talents and persuasive capacity on the part of the consultant.

(iii) *Effective method of training and development* : It is generally believed that consultants cannot be trained in class-rooms and can be developed only by on-the-job training method requiring individual tutoring. While this ideal situation would improve the quality of consultants, the need for developing a large number of consultants, in tune with the demand for such professional service, requires a systematic approach to training involving group instructions as in other professional training activities.

Personal Observations for the Selected Issues

(a) Scope of consultancy services should be properly selected and the contents should be carefully designed in accordance with the prevailing conditions, needs and requirements of the industries and business enterprises of a country. Classification about sorting out of suitable scope of consultancy services could possibly be developed in relation

to the different stages of industrial/economic development. Intensive study for indentifying suitable scope of consulting activities in relation to different stage of industrial development would be very useful for the benefit of APO (Asian Productivity Organisation) member countries and NPOs (National Productivity Organisations).

(b) Well-prepared publications would be useful for disseminating information as to the usefulness of consultancy services. Model plant system is also effective for demonstration purposes. While ample opportunities should be provided for consultants for their promotional activities by each NPO without violating professional ethics, it is recommended that APO should extend effective assistances to NPOs in various ways.

(c) Positive actions are strongly recommended for promoting prestige and social standing of consultants by NPO and other related organisations. Their activities and achievements should frequently be made public and ample opportunities be given for them to appear in public to demonstrate their successful cases. Remuneration system should be reviewed and a proper consideration should be given to better treatment and working conditions in order to reduce the high ratio of turn-over of consultants. Possibly different salary systems be tactfully applied for consultants and other staff in consulting organisation. Control of consultants' workload assignments and activities as well as evaluating their performance should be carefully designed and applied since consultants are engaged in highly professional jobs and they are different from other administrative or clerical staff. It would be useful if a clearing house be organised for exchanging useful information and experiences among NPOs for the benefit of better administration and management of consulting organisation. To organise an international association of consultants in Asian region might be an effective means for promoting social and public recognition of this profession. Careful screening system is recommended for eliminating unethical and incapable consultants in order to maintain and promote prestige and dignity of consultants.

(d) Whether to recruit a college graduate or an experienced specialist as a junior consultant, depends on different policies and beliefs of different persons and organisations. In any event, a concrete manpower development programme should be established by each consulting

organisation. Since most of the so-called consultant training courses are nothing more than slightly modified management development/training courses and do not contain intensive and practical guidance on professional know-how and means to improve professional skills, a special survey and study should be made for the development of suitable curricula in this line. Intensive, yet organised, on-the-job training at consulting firms in advanced countries would be most effective, if it is applicable. □

Electric Discharge Machining : Alternative to Precision and Quality

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Introduction

Electric Discharge Machining (EDM) is a process in which metal is removed by the controlled thermal action of electric current on conducting materials. In recent years, more progress has been made on this technique than on any other metal-removal process. EDM is a very useful method for machining the new "super-tough" materials and "space-alloys", as well as for the manufacture of tools, dies, and other intricate parts. With technological advances in equipment and applications and a better understanding of its advantages and limitations, the EDM process is being adopted by many metal working firms as an important means of achieving greater design flexibility, reduced costs, and improved products.

In the EDM process (Figures 1A, 1B and 2), metal removal is caused by a series of electric sparks directed from the tool to the work-piece. The transient spark discharges occur at a rate of from 1 to 1500 kilocycles per second in the space between the positively charged workpiece and the negatively charged electrode (i.e., the tool). The sparks erode the workpiece in such a way that the erosion develops into a replica of the electrode.

During erosion, the workpiece and the working portion of the electrode are submerged in a dielectric fluid. This liquid bath serves to transfer the spark in a controlled direction, remove the eroded material, prevent fusion of the electrode with the workpiece and erosion particles, and cool the electrode. A spark discharge occurs when the electrical potential between the tool and the workpiece becomes sufficient to cause breakdown of the dielectric medium. The transient spark travels the shortest distance between electrode and workpiece, hence erosion of the workpiece exactly follows the configuration of the electrode.

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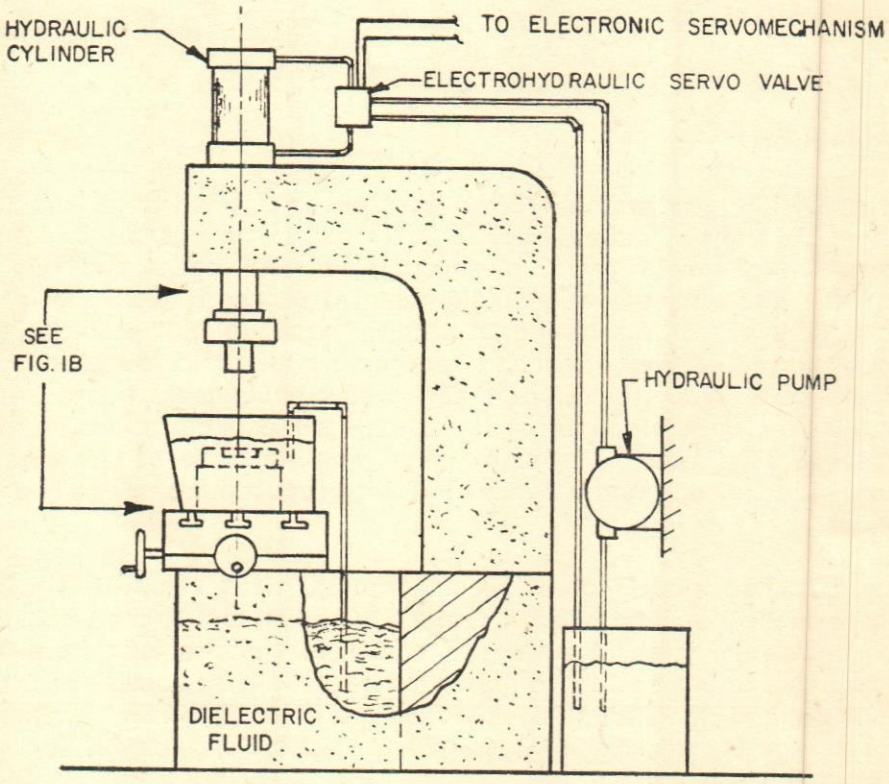

Fig. 1A—Electric Discharge Machine

The sparks erode the electrode as well as the workpiece, though usually at a different rate. When a spark strikes the workpiece (See Figure 2) microscopic metallic particles are vaporised, electrically energised, and finally released. These charged particles move rapidly through the electric field due to the attraction of the oppositely-charged electrode. Most of the particles are washed away by the fluid, but some strike and mechanically erode the electrode. Some wear is also produced as a result of the intense thermal effects generated at the electrode surface as a spark is generated and, as a result, a minute crater is formed at the point of spark origin. Basically, the EDM machine is composed of a solid bed-type machine with a tank (to retain dielectric fluid) attached to a work table. This assembly is positioned under the electrode by a

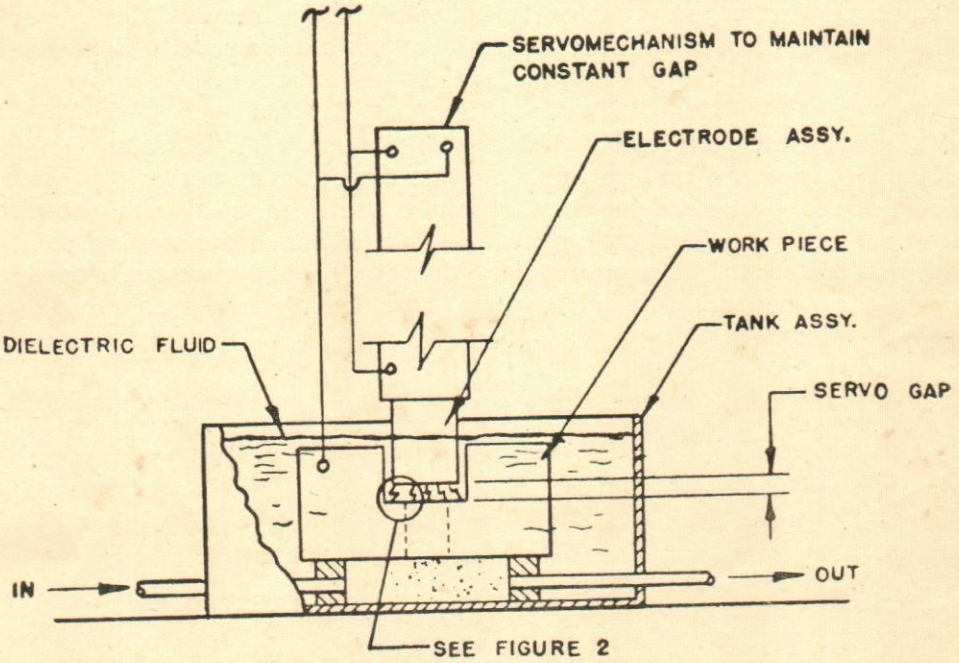

Fig. 1B– Diagram of EDM

precision X-Y co-ordinate lead screw system. As illustrated in Fig. 1A a ram with a specially designed chuck to position and hold the electrode travels perpendicularly to the work table face. Electrode feed rate is regulated by a low frequency electro-hydraulic servo-mechanism.

The spacing between the workpiece and electrode is critical, and repetitive accuracy and efficiency of machining can be achieved only when a constant and reliable gap-distance is maintained. For this reason the feed of the electrode is controlled by a servo-mechanism which advances or retracts the tool by sensing deviations in the gap-voltage.

In EDM, the removal rate of material is dependent on the size of the machining area, the shape and composition of the workpiece to be eroded, and such electrical parameters as current frequency, duration of discharge, and properties of the electrode material. As a rule, high-

amperage discharges produce a rapid rate of metal removal, but generally yield rough surface finishes. To achieve smooth surfaces, it is necessary to use a reduced current and increased spark frequency.

A recent study indicates that average metal removal rates from the workpiece are inversely proportional to the 1.25 power of the melting point of the workpiece material, whereas metal removal rates from the tool are inversely proportional to the 2.25 power of the melting point of the tool material. The proportionality factors in each case are dependent upon tool material, dielectric fluid, machine tool, power supply, and servo system.

It is important to emphasise at the outset that the direct costs of EDM

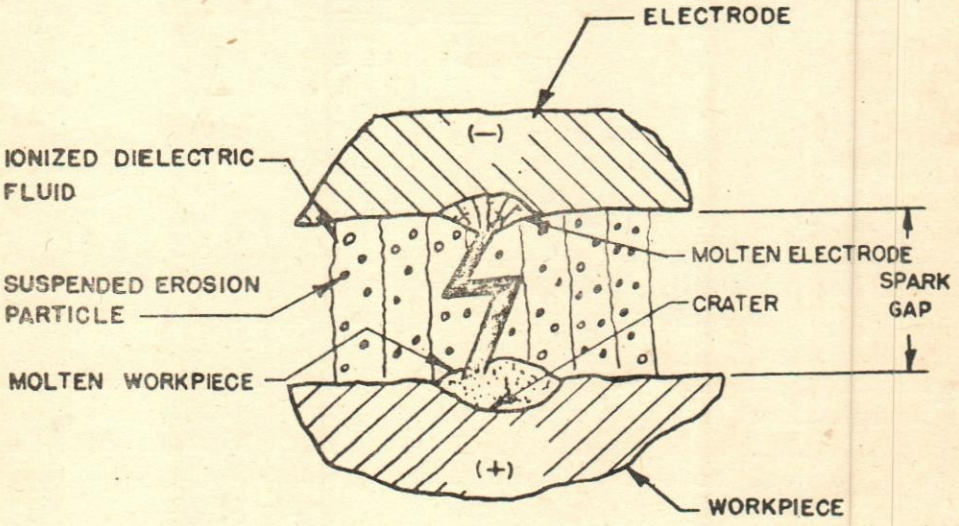

Fig. 2 –Spark Erosion

and conventional metal removal methods should not be compared. EDM should generally be considered as complementary to conventional methods, advantageous in selected situations.

Basic Elements of EDM

The EDM process consists essentially of the following basic elements :

1. Electrode
2. Power Supply System
3. Dielectric Fluid
4. Machine Tool

1. *Electrode*

In the EDM process, the electrode is the cutting tool and its configuration is reproduced in the workpiece when power is applied to the system. Though any electrically-conductive material can be used as an electrode, selection is based mainly on machinability, wear ratio, and cost. Common electrode materials are aluminium, brass, carbide, copper, carbon, etc.

Machinability in the electric discharge process is a measure of how much and how well the pulses that are delivered to the electrode by the power supply system are converted into sparks that do the eroding work. Not every pulse, however, is converted into a spark. Some electrode materials will actually transmit less than one percent of the possible sparks and the intensity of such a discharge may be uneven. Compared with other electrode materials, graphite has the best machinability rating. Wear of an electrode results in a gradual change in its dimensions; if the wear becomes excessive, the electrode must be removed and replaced.

Thus, tools exhibiting high wear rate will be costly in the long run because of the necessity of frequent replacement and long machine downtime. Since the wear of the EDM tool is inversely proportional to the melting point of the tool material, graphite appears superior to most materials as an EDM tool because of its high (6300°F) melting point; however, there are some disadvantages in its use. Despite the advantages of graphite electrodes, there are the following drawbacks : (1) When the electrode is machined, the work atmosphere becomes saturated with

fine graphite dust, a source of contamination to personnel and nearby equipment. (2) Being fragile, graphite tools require very careful handling and storage to avoid chipping or breaking the finished electrodes. (3) Graphite is susceptible to thermal shock. (4) Graphite contaminates dielectric fluid making it essential to change filters very often.

There are two techniques of electrode design that merit special note. For the introduction of holes of various shapes, an electrode may be used which is comprised of several stages. Each stage would be designed so that the most efficient metal removal rate would be achieved. In this way, a small cross-section of the tool would be used to begin a pilot hole and successively larger cross-sections to produce shapes closer to the final configuration of the hole. To produce a die, the working end of the mating punch can be coated or "tipped"* with an electrode material and the punch itself can thus be used to finish machine the die cavity.

In conclusion, it must be noted that the ultimate selection of an electrode material is often based on the ease with which it can be fabricated rather than on its EDM capabilities. To facilitate solving the fabrication problems, many manufacturers are concentrating on providing improved electrode materials which are less expensive and easier to machine.

2. *Power Supply System*

Several basic types of circuits used for providing pulsating D.C. Current to EDM machines are illustrated in Figure 3. No one particular type is best for all machining conditions. The most suitable circuit depends on the type of dielectric fluid, the nature of tools used, and the type of finish required.

One type of power supply unit, widely used in European EDM practice, is a resistance capacitance (RC) or relaxation circuit which utilises a high-energy discharge at low frequency. This self-oscillating circuit operates at approximately 70 to 180 volts with an open-circuit voltage of up to 300 volts. A voltage from a constant source is used through a resistance to charge the capacitor; the capacitor is charged to a level sufficient to break down the dielectric at the gap between tool and work-piece. Since the voltage across the capacitor in an RC circuit is the

*A tip of electrode material can be cemented to the punch with a conductive epoxy adhesive.

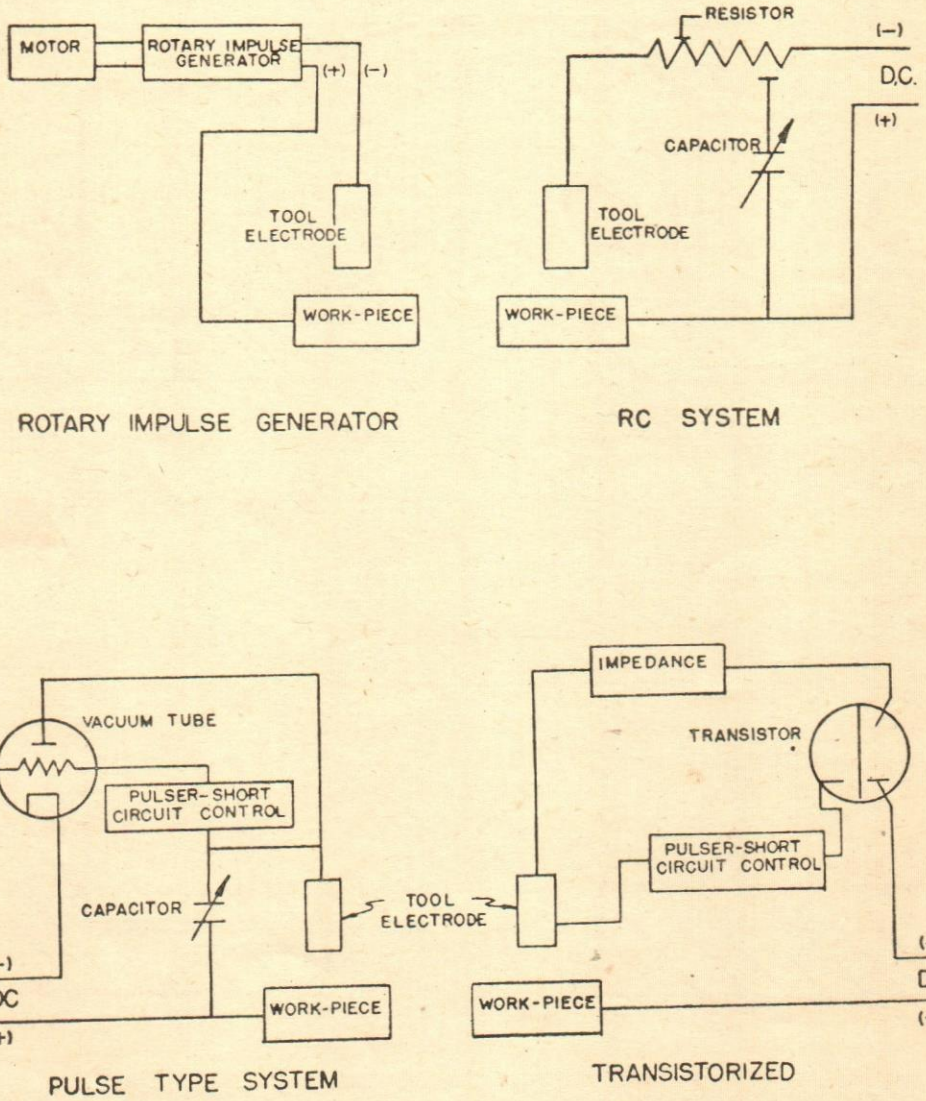

Fig. 3—D.C. Circuits For Pulsating EDM

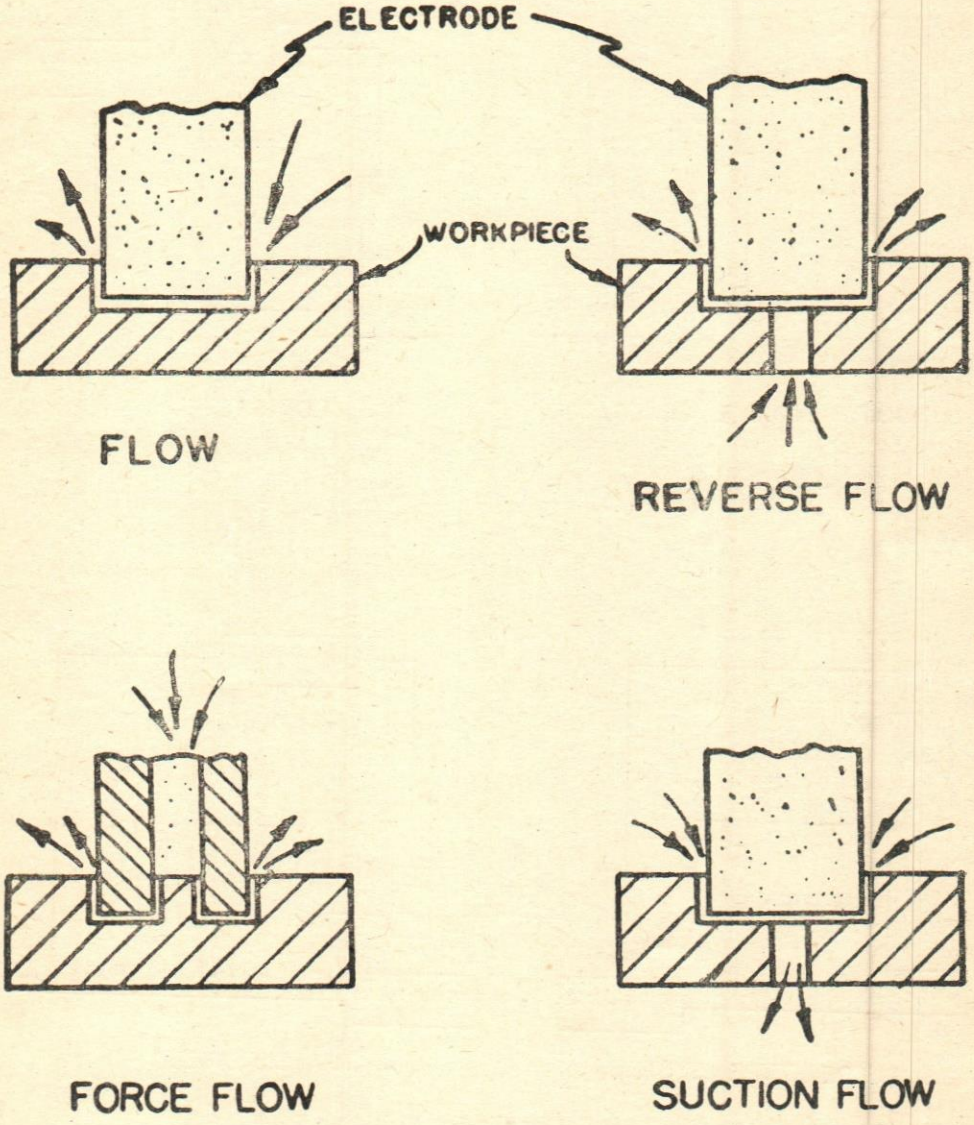

Fig. 4—Methods to Flush Eroded Particles from Machining Area

same as that across the arc gap, a charging resistance must be so chosen that the capacitor is not again charged to the arc voltage before the dielectric fluid in the gap has had time to become deionised. If this is not done, a continuous arc is formed from tool to workpiece and no machining occurs. The need for charging resistance in an RC circuit creates "dead" time and thus reduces the number of discharges possible per unit of time. While such circuits are simple, reliable, and relatively low in cost, it is necessary to use low machining rates to achieve smooth surface finishes.

The pulse type circuit incorporates vacuum tubes or transistors (in place of resistance elements) to provide minimum resistance during charging of the capacitors and maximum resistance during discharge. In this way, switching is accomplished at frequencies approximately 10 times greater than those used in RC circuits. The pulse type circuits provide a high frequency low energy discharge operating at about 20 to 60 volts with an open circuit voltage of 70. While such circuits are more complex, they permit greater flexibility and control, and are capable of producing finer surface finishes at relatively-high metal removal rates.

Transistorised pulse-type power supply units are not available having a wide range of frequency adjustment and variable current control for either relatively high or low material removal rates depending on the surface finish required. Fixed frequency, rotary impulse generators (using rotating motor generator sets) can be obtained for high material removal rates with a correspondingly rough surface finish. While power output can be reduced to improve the surface finishes, these units are usually used for rough machining of forging dies while the finish machining is performed with higher frequency power supply units.

Static impulse generators employ a high frequency, vacuum tube (oscillator and amplifier) power source, coupled to a series capacitor and a shunt silicon diode. The capacitor is charged through the diode during half of each cycle; during the other half of the cycle, the sum of the output voltage and the charged capacitor voltage is applied to the machining gap. Since there is zero potential difference across the machining gap while the capacitor is charged, deionisation of the dielectric can take place while the capacitor is being charged.

3. *Dielectric Fluid*

The dielectric fluids used for EDM serve several important functions : (1) The fluids constitute an integral part of the discharge between the tool and the workpiece. Ions and uncharged molecules of the fluid are largely responsible for initiation of the discharge and for providing the conductive path of the discharge. The bulk of the fluid serves to confine the spark path to a restricted zone. Thus both the amount of energy transferred and the size of the crater produced are influenced by the properties of the dielectric.

(2) To flush the eroded particles out of the machining area, the fluid is either forced through hollow tools, through holes in the workpiece, between the tool and the work, or by oscillating the tool (Fig. 4). It may be noted that filtration of the fluid is essential to prevent electrical short circuiting between the work and tool. The filter removes particles having diameters greater than a small fraction of the working gap distance and is essential for finishing operations. This action also minimises energy losses attributable to "remachining" of the debris.

(3) The dielectric acts as a coolant for both the workpiece and the tool. Dielectric fluids commonly used for EDM include different types of oils : kerosene, transformer oils, lubricating oils, various other petroleum distillate fractions, and expensive silicon-base oils. Distilled or deionised water, carbon tetrachloride, and some compressed gases have been used in certain instances. However, low-cost petroleum fractions have been used most often and perform quite well, especially when used with graphite tools.

Recently, the use of a dielectric solution consisting essentially of triethylene glycol, water, and monoethyl ether or ethylene glycol has given results with metallic electrodes which are superior to those obtained with conventional hydrocarbons.

4. *Machine Tool*

Productive efficiencies obtainable with EDM depend upon the interaction of all related elements : the machines, their servo-feed controls and power supply units, the workpiece materials, and the tooling and dielectric.

Machine tools used for EDM have undergone considerable changes. Originally, only limited results were realised from machine tools which were converted for EDM use. Currently, EDM machines are available in a wide range of sizes and types. Desirable machine features include negligible lateral deflection when subjected to flow of dielectric, precise movements of the ram of the order of 0.002 to 0.0004 inch with a minimum of friction, and the minimum amount of vibration transmission to the tool. Since EDM transmits little or no mechanical forces, massive tool members and heavy construction to support the ram or spindle are not required.

The important component of any EDM machine tool is the servo-feed control mechanism. The functions of these elements are to maintain automatically the required gap between the tool and the work, to advance the tool into the work as the operation progresses, and to sense and correct any short circuiting between tool and the work by first withdrawing and then returning to the tool. Precise control is essential because if the arc gap is too large, ionisation of dielectric and electrical discharge machining cannot take place; if the gap is too small, tool and work might bond together. This control is achieved by comparing the average gap voltage to a predetermined voltage. The difference between these two voltages is used to locate the tool by means of a servo-mechanism system. Electro-mechanical types of servo-feed control mechanisms formerly used are now being replaced by electro-hydraulic systems that offer faster response rates.

Advantages

Though in its infancy, EDM has proved to be a very important machining process in the metal working industry, it is currently being applied successfully and profitably in many industrial problems. Some of the major benefits of EDM are :

1. Any electrically conductive material, regardless of the physical properties, can be machined by EDM. This has two important implications :

(a) EDM can be performed as a final operation after hardening, thus eliminating distortions, strains, and mechanical fractures in the workpiece resulting from heat treatment.

(b) In many instances, die materials can be improved and productivity increased to a great extent. For example, carbide dies can be made by EDM at approximately the same cost as conventionally-made steel dies.

2. There are no cutting forces involved in EDM since there is no contact between the tool and the workpiece. Thus, very fragile and complex parts can be machined.

3. The ability of this process to produce intricate parts of various shapes and sizes have been very advantageous in eliminating costly split sectioning required in other methods.

4. The EDM process offers great potential in maintenance and repair of tools and dies. It is ideally suited as a means of correcting completely heat treated and finished tooling and out-of-tolerance cavity work requiring minor repair. Substantial savings have been realised in the resinking of forging, injection-moulding, die-casting, cold-heading, and stamping dies.

5. The non-directional finish produced by EDM forms a natural reservoir to sustain lubricants. Many studies have indicated that this factor might be responsible for extending the life of EDM-produced dies.

6. The EDM cratering types of surface is considerably easier and more economical to polish. Normally, grinding roughness is characterised by linear surface irregularities that are composed of a high and low variety of wavy surfaces, which require additional polishing or lapping effect for reduction or removal.

7. Since the erosion action is completely free of mechanical forces, deflection of the electrode is not encountered and set-up errors are much smaller in magnitude than in conventional machining.

8. EDM can reduce the cost of certain operations such as heat treating, straightening, annealing, deburring, fitting, keying, stoning, and finishing.

Disadvantages

Though EDM has many advantages, it has its own limitations. To begin with, it is not a mass-production process because metal removal rates

are very slow, varying from as little as 0.001 cubic inches per hour for precision machining with smooth surface finishes to 15 cubic inches per hour for rough machining with poor surface finishes. Usually large volumes of material are removed by conventional methods and EDM is used for finishing.

Another possible limitation of the EDM process is that the material to be machined must be electrically conductive. Also, under normal operation, the holes produced are tapered. However, this tapered effect can be controlled within usable tolerances for most applications to as little as 0.001″ in 1/4 inch with low currents and fine finishes. However, this further reduces the metal removal rate. Rapid tool wear can sometimes be a factor in deciding whether or not to use EDM. Discharge machining produces a highly stressed hard surface layer on heat treatable steels and occasionally tools made by EDM fail. This effect, however, may be minimised by reducing the depth of the hardened layer or by using lapping or grinding to remove the hardened zone.

Accuracy and Surface Finishes Obtainable with EDM

The accuracy that can be obtained with EDM depends on the machine tool, the set up, the tool and tool-wear rate, and the amount of overcutting. Overcutting is a function of the open circuit voltage and the amount of charge transferred in the spark when the tool and workpiece materials are kept constant.

To maintain close tolerances, the amount of clearance that will be produced by EDM must be predictable. Most manufacturers can provide overcut charts to show the amount of clearance produced as a function of currents. With such charts, it is possible to accurately predetermine the electrode sizes that will machine openings within 0.0001 inch of the amounts of overcut shown on the charts for pulse type power supply units. This accuracy can be affected by the size and quantity of eroded particles in the arc gap. For a specified frequency selector setting, the current alone is the determining factor as to the clearance produced between the electrode and machined surface.

Surface finishes obtainable with EDM are dependent upon metal removal rates. With very low metal removal rates such as 0.001 cubic inches

per hour, surface finishes of 2 to 4 micro-inches can be produced. Conversely, with very high metal removal rates, such as 15 cubic inches per hour, extremely rough surface finishes of the order of 1000 micro-inches can be realised.

The surface finishes can be controlled by varying the amount of charge transferred in each spark between the tool and work. This may be achieved in a variety of ways, depending on the type of the power supply used. With a pulse type power supply unit, the charging part of the cycle and the interval between charging pulses can be predetermined. Then, the charging cycle and the interval between the charging pulses should be chosen so that the maximum metal removal rate can be realised. The degree of surface finish produced is also affected by the tool material, work material and the dielectric fluid used.

Applications

EDM is being widely used by both small and large industries, primarily for the manufacturing of dies and moulds. Applications often permit the production of better parts and dies at less cost and greater design flexibility. However, the use of discharge machining generally depends on the quantity and complexity of the components. It is often economically efficient to use a combination of conventional machining and EDM. With current models of EDM units, one power supply can operate two EDM machines and one operator can supervise a multiple unit installation.

The final machining of cavities in dies for forging, injection moulding, die casting, cold heading, extrusion etc., is generally an excellent application for EDM. However, again this depends on the quantity required and the complexity of the workpiece.

For sinking work or washed-out dies EDM can sometimes be used profitably. By minimising or eliminating the need for hand finishing of forging dies, the number of man-hours required has been reduced significantly.

Additional savings often result from the reduction or elimination of secondary operations required on parts that are cast or moulded in

dies made by EDM. The process permits one-piece design, since intricately shaped contours can be cut in solid blocks, thus reducing the cost below that of sectionalised design.

The production of cutting-edge dies, including progressive dies, compound dies, and four-side dies for blanking, piercing, notching, trimming, lancing and similar operations, is an important and rapidly growing field of application for EDM. In general, the more complex the part required, the more advantages offered by EDM. Punches can be used to make their own mating die openings in hardened steel or other materials. Therefore, within the capabilities of the power supply units the die openings can be duplicates of the punch shapes and can serve as a clearance between the punch and die within uniform and controllable limits. Thin sections and irregularly shaped openings can be cut from the solid without the costly time-consuming job of making and fitting together inserts. With EDM the die material has practically no effect on the cost of making the dies; with the punches and dies hardened prior to EDM, no further heat treatment is required.

Potential of EDM

Many research and development programmes are currently being conducted to improve electrode materials and electrode fabricating systems, to create better electronic circuits that will yield finer surface textures, to design efficient dielectric filtering units, to make use of ultrasonics in order to reduce electrode wear, and to utilise the concept of Numerical Control on EDM machines. The solidarity of EDM is presently being formulated on local and international levels. There is much discussion on the suggestions for the world standardisation of the EDM technological language and the proposal of a system for EDM surface texture measurements.

Based on its present-day applications, the development and new applications in sight, and the emphasis on research and development by many manufacturers and universities, electric discharge machining will be a necessity for tomorrow. □

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□

Unused Inventories in Petroleum Enterprises of Central Government

Ram Prakash*

Introduction

On 31st March, 1977 there were 11 Central Government enterprises engaged in exploration of oil and gas, refining of crude oil, blending of additives and marketing of petroleum products. In these enterprises Rs. 649 crores** were invested as equity and loan. Out of every 13 rupees invested in all the manufacturing enterprises, roughly Re. one is in petroleum industry. These enterprises account for nearly 36 percent of total gross profit of about Rs. 581 crores earned in 1976-77 by all the enterprises, producing goods.

In 1966-67, there were only two undertakings, viz., Indian Oil Corporation Limited (IOC) and Oil and Natural Gas Commission (ONGC) with total employed capital of about Rs. 279 crores. The turnover of these two enterprises in that year was Rs. 367 crores. Over the period the number of undertakings increased to eleven and capital employed to Rs. 801 crores, i.e., by 187 percent. The turnover grew to Rs. 4622 crores, i.e., nearly by 13 times the sales in 1966-67. ONGC is the biggest undertaking of this group with paid-up capital of Rs. 241 crores as on 31.3.77 out of the total of Rs. 401 crores for the entire group. IOC is the second biggest company of this group with paid-up capital of Rs. 82 crores. The other enterprises with their year of incorporation (in bracket) are Cochin Refineries Limited (1963), Madras Refineries Limited (1965), Hydro Carbon India Limited (1965), Lubrizol India Limited (1966), Indo-Burma Petroleum Corporation Ltd. (1972), Hindustan Petroleum Corporation Ltd. (1974), Indian Oil Blending Ltd. (1974), Bharat Petroleum Corporation Ltd. (1976) and Caltex Oil Refining (India) Ltd. (1976).

Level of Inventories

The average value of inventories held by this group of enterprises during 1976-77 was Rs. 443 crores as compared to Rs. 62 crores in

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** One crore = 10 million

1966-67 The inventories as a percentage of total produce fell from 18 in 1966-67 to about 10 in 1976-77. The cost of sales has grown from Rs. 343 crores (1966-67) to Rs. 4413 crores (1976-77). The data on inventories, cost of sales and their associated relationships for the available last eleven years are summarised in Table 1. The changing pattern of inventories in relation to cost of sales have been graphically presented in Figures 1 and 2.

Table 1

Year	Rs in crores		Inventories as percentage of cost of sales	Inventories in terms of months of cost of sales	Inventories turnover rate 2÷3
	Cost of Sales	Value of average inventories			
1966-67	343.45	62.11	18.1	2.17	5.53
1967-68	460.35	70.39	15.3	1.84	6.54
1968-69	558.64	76.53	13.7	1.64	7.30
1969-70	700.17	89.56	12.8	1.53	7.82
1970-71	821.32	99.83	12.2	1.46	8.23
1971-72	979.90	108.09	11.0	1.32	9.07
1972-73	1124.27	113.76	10.1	1.21	9.88
1973-74	1485.25	171.72	11.6	1.39	8.65
1974-75	2786.10	300.20	10.8	1.29	9.28
1975-76	3530.16	384.31	10.9	1.31	9.18
1976-77	4413.42	443.09	10.0	1.20	9.96

A quick guide to efficient management of inventories is stocks turnover ratio. It reflects the "mileage" obtained from the money tied up in stocks and is calculated after dividing the annual usage or cost of sales by average inventories. Over the eleven years under study, gradual improvement in the inventory turnover ratio is seen from 5.53 to 9.96. In the first seven years larger volume of sales were covered by the same amount of inventories. Fig. 1 in this period shows some tendency of concave formation of inventories and cost of sales relationship curve. In 1973-74 after international oil crisis, inventories increased considerably and the turnover ratio fell from 9.88 in 1972-73 to 8.65. The stocks appear to have again become active in 1974-75 and 1975-76 as seen from higher inventories turnover ratios of 9.28 and 9.18 respectively. In 1976-77, the ratio reached at the highest level ever achieved. This

trend of overall improvement is further corroborated by the fact that gap between cost of sales and average inventories as seen from Fig. 2 markedly increased over the eleven years. The inventory holdings in terms of months of cost of sales were equal to 1.2 in the eleventh year as compared to 2.17 in the first year of the period. On the whole, lesser

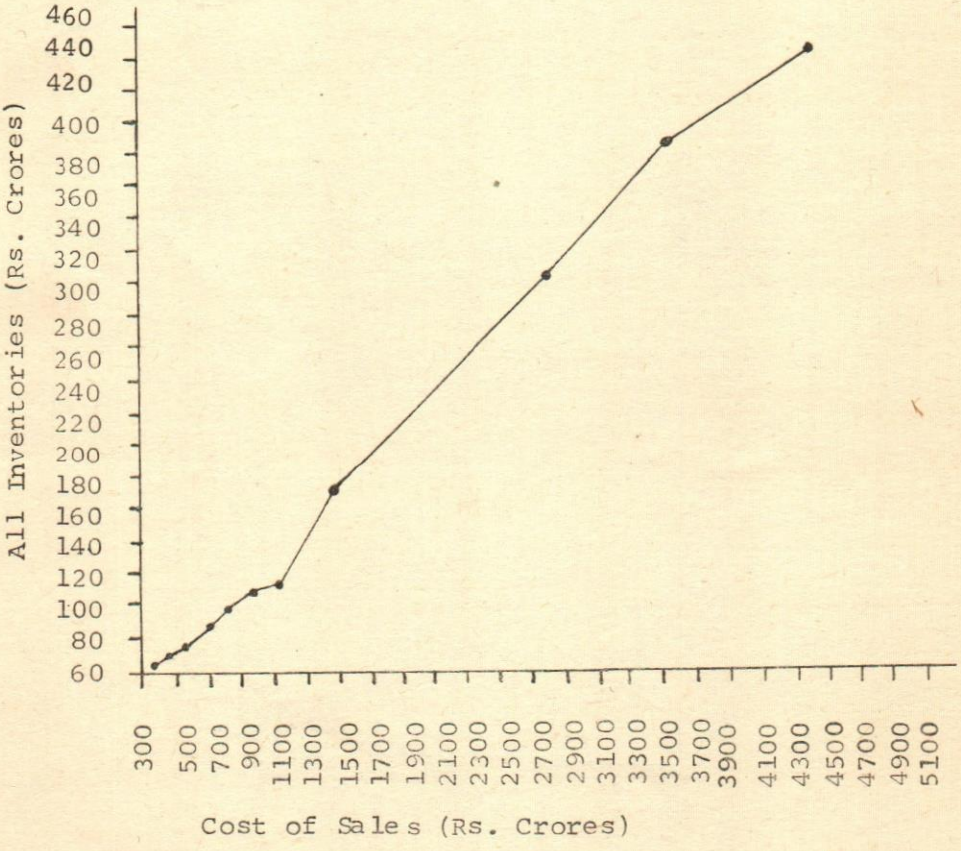

Fig. 1 : All Inventories and Cost of Sales Relationship - Petroleum

levels of inventories covered larger volume of produce. If judged from the turns ratio alone, the inventory performance in this group of

enterprises is quite good as compared to the companies in USA. In America, the ratio of net sales to inventory for 37 petroleum integrated

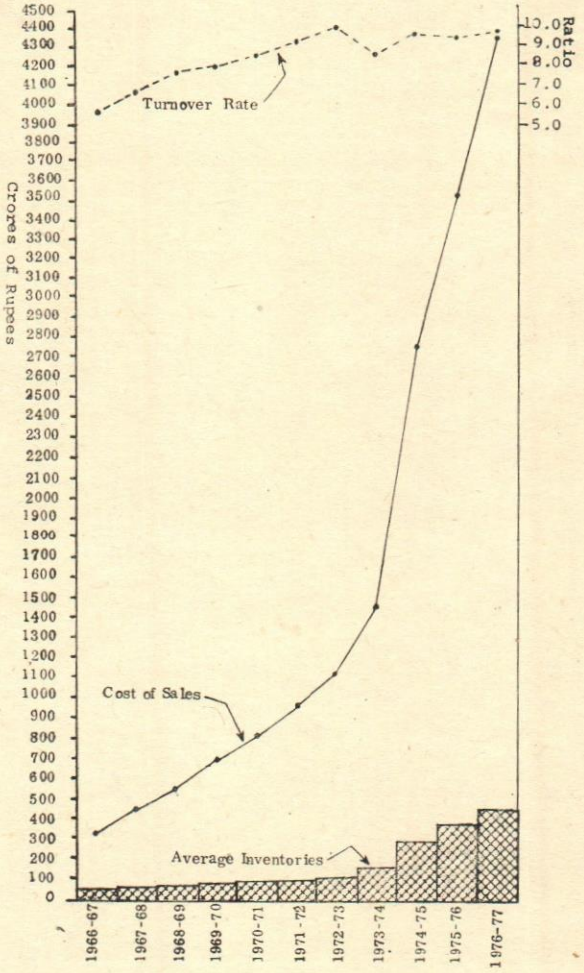

Fig. 2 : Inventory Chartwatch—Petroleum

corporations shows a range of 11.7 to 3.7 upper and lower quartile, the medium being 6.3. (*Encyclopaedia of Management,* edited by Carl Hayel; pp. 228-29: Ratio compiled by Dun and Bradstreet Inc.).

Inventory Components

The behaviour pattern of different components of inventories can be studied from the data on the three inventory components and other associated aspects as summarised in Table 2. The graphical presentations of data are made in Figs. 3, 4 and 5.

Raw Materials : The turnover ratio of crude materials and spares in relation to their consumption has greatly improved during the first nine

Table 2

Year	Cost of sales	Rs. in crores				Turnover Ratios	
		Value of materials & spares consumed	Av. inventories of			Materials & spares to their consumption 3÷4	Finished goods to cost of sales 2÷6
			Raw materials & spares	Work-in-process	Finished goods		
1	2	3	4	5	6	7	8
1966-67	343.45	172.07	35.43 (2.47)	1.34 (0.05)	25.34 (0.89)	4.86	13.55
1967-68	460.35	230.63	38.70 (2.10)	1.12 (0.03)	30.57 (0.80)	5.96	15.06
1968-69	558.64	283.73	45.96 (1.94)	1.29 (0.03)	29.28 (0.63)	6.17	19.08
1969-70	700.17	355.05	57.27 (1.94)	2.17 (0.04)	30.12 (0.52)	6.20	23.25
1970-71	821.32	415.56	62.36 (1.80)	2.29 (0.03)	35.18 (0.51)	6.66	23.35
1971-72	979.90	487.41	64.64 (1.59)	2.28 (0.03)	41.17 (0.50)	7.54	23.80
1972-73	1124.27	577.06	67.98 (1.41)	2.44 (0.03)	43.34 (0.46)	8.49	25.94
1973-74	1485 25	915.86	85.09 (1.11)	6.74 (0.05)	79.89 (0.65)	10.76	18.59
1974-75	2786.10	1874.20	134.72 (0.86)	13.12 (0.06)	152.36 (0.66)	13.91	18.29
1975-76	3580.16	2389.75	192.13 (0.96)	13.20 (0.04)	178.98 (0.61)	12.44	19.72
1976-77	4413.42	2836.20	237.60 (1.01)	15.42 (0.04)	190.07 (0.52)	11.94	23.22

Figures in parentheses relate to inventories in terms of months of consumption of materials and spares for crude materials, and of cost of sales for work-in-procress and finished goods.

years of the period. The said turns ratio, in the first year was 4.86 and in ninth year, it was 13.91. In the eighth (1973-74) and ninth (1974-75) years improvement was at an accelerated rate probably due to greater emphasis on optimum use of crude inventories, in the post-oil crisis period. During the last two years the stocks of crude materials increased disproportionately to the increase in their consumption and, as a result, the turnover ratio fell from 13.91 in 1974-75 to 11.94 in 1976-77, but was still higher than the highest of the first eight years. Fig. 3 shows sharp increase in stocks as compared to their consumption in the last two years. This indicates the importance of constant watch over inventories.

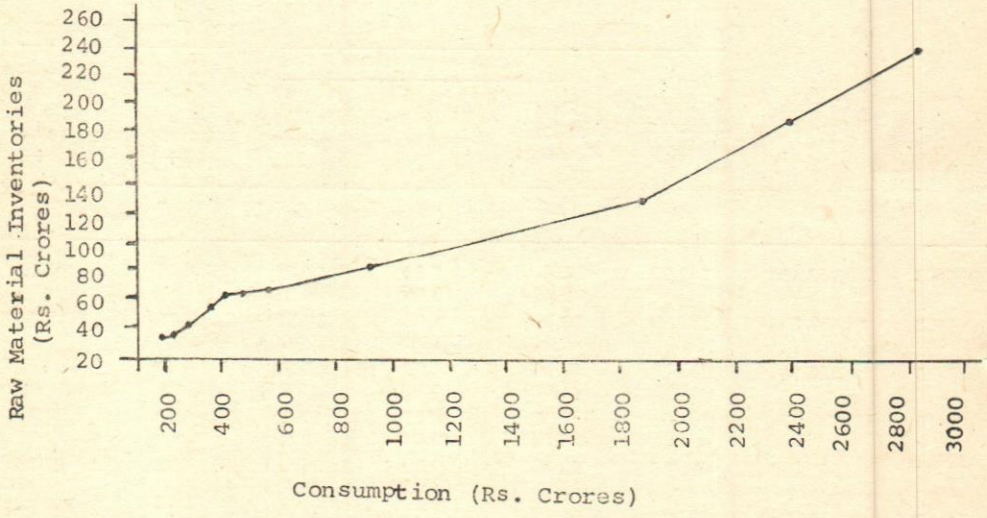

Fig. 3 : Inventories of Raw Materials & Spares and their Consumption Relationship—Petroleum

Work-in-Process : The inventories of WIP during the period of eleven years had never exceeded 1.8 days of the cost of sales and mode was 0.9 days. The trend in WIP inventories and cost of sales over the eleven years has been shown in Fig. 4. Keeping in view the fact that the quantum of work-in-process is mainly dependent on factors like production cycle, sequence of operation, pattern of sales orders and type of raw materials, the holding of inventories in this category appears to be satisfactory.

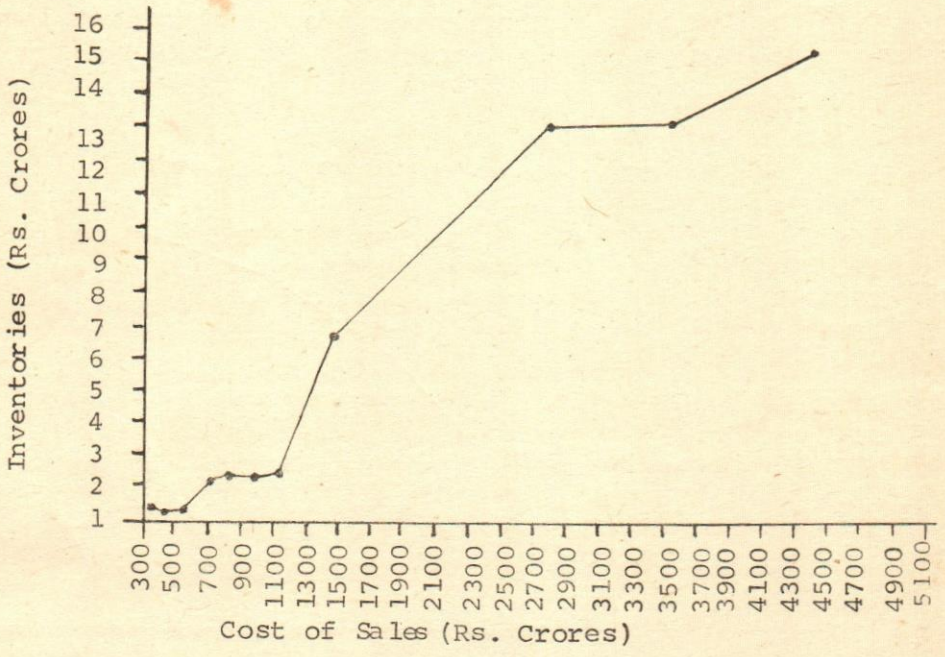

Fig. 4 : Inventories of Work-in-Process & Cost of Sales Relationship—Petroleum

Finished Goods : In this category of stocks the holding had varied between 27 to 14 days of sales. In the first seven years, the inventory turnover ratio has shown progressive improvement from 13.55 to 25.94. Thereafter it fell to 18.59 in 1973-74 and to 18.29 in 1974-75. In the last two years it improved first to 19.72 and then to 23.22, but did not reach the level of 1972-73. In finished goods stocks two important developments seem to have taken place. Firstly, due to excessive stocks in the initial year of the study it was possible to reduce the stocks to a level of 13.8 days under conditions of stable supply. Subsequently, we had world-over fuel crisis which sharply increased the prices of petroleum products and created insecurity of supply conditions. This had the chain reaction of reduction in demand. These resulted in second development of increase in stocks of finished goods in 1973-76. The inventories and sales curve in Fig. 5 also show a concave formation in first seven years and thereafter the stocks of finished goods increased

sharply. In the last year of the period under study, however, some tendency of reduction in the relative position of stocks *vis-a-vis* sales is seen in Fig. 5.

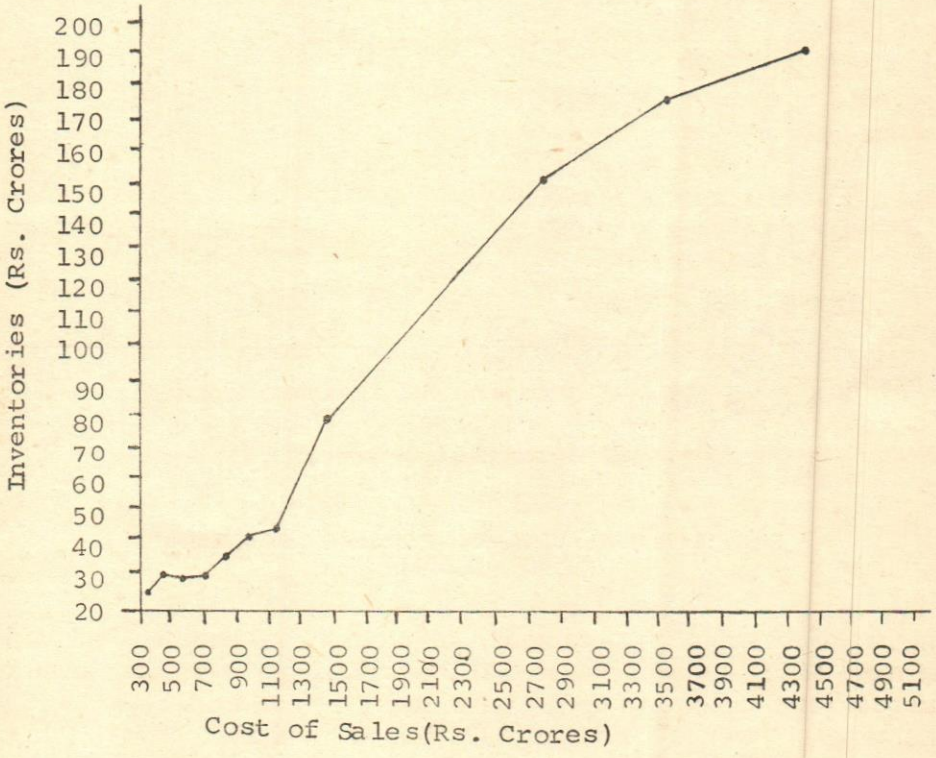

Fig. 5: Inventories of Finished Goods & Cost of Sales Relationship—Petroleum

Behaviour Pattern : Scientific management of inventories suggests that with increasing consumption of sales relatively lesser volume of inventories are needed, and under effective management, inventories should move in square root relationship with sales/usage. The extent to which this law of economies of scale operates can be ascertained by fitting the time series data of inventories and usage through Regression

Analysis to the general form of equation $I = a + bS^{\beta}$ model. Here I stands for inventories, a—safety stocks, b—policy variable and S for sales/usage. The value of β thus arrived at will indicate the degree of economies of scale in the holding of inventories. Unfortunately, there are statistical difficulties in estimating by linear regressions an equation of the form $I = a + bS^{\beta}$, and as such a general form model cannot be applied. Under these circumstances it would be legitimate to think of alternative models to indentify the extent of economies made by the management in holding of inventories over the eleven years under study. Experience has given some idea of approximate limits, within which, inventories *vis-a-vis* the derived demand would move. This approximate limit suggests three possibilities. One, inventories may move in constant ratio with their usage. Second, according to established belief under ideal conditions of effective management, inventories should move in square-root relationship with their usage. The third alternative is that inventories increase in between the two extremes. These trends in time series data can be captured through three models :

i) $I = a + bS$

ii) $I = a + bS^{1/2}$

iii) $I = S$ with $\frac{1}{2} < \beta < 1.0$

In the model (i), inventories form a constant ratio with usage. In (ii), stooks are in square-root relationship to derived demand. The model (iii) holds the assumption that economies of scale exist, but are not as great as those indicated by the square-root. The application of three models will give sufficient insight into the inventory behaviour, and assess the extent to which there had been economies of scale in inventory holding.

Application of Model I : The inventories of raw materials and spares were correlated with their usage and those of work-in-process and finished goods with cost of sales according to the linear model $I = a + bS$ through regression analysis, for five groups of years 1 to 7, 1 to 8, 1 to 9, 1 to 10 and all the eleven years. Since the holding of stocks under WIP category is nominal as discussed earlier, its further examination is not considered necessary. The important results in respect of other categories are summarised in Table 3.

In the inventories of crude materials there is strong evidence of economies of scale. In all the above three groups the intercept 'a' is five and is significantly different from zero at 95% confidence. The R^2 value is also more than .9. The analysis for the decade and first nine years also reveals similar trend.

In stocks of finished goods over the first seven years there is definite evidence of economies of scale. The intercept 'a' is +ive and significantly different from zero at 95% confidence level, thus showing that ratio of average inventory to cost of sales is more than their ratio of marginal rates of changes. But analysis relating to 1 to 8, 1 to 9,

Table 3 : Simple Regression of Inventories to Usage : I = a + bS

Parameters for Analysis	*1966-67 to 1976-77*		*1966-67 to 1973-74*		*1966-67 to 1972-73*	
	Materials & Spares	*Finished goods*	*Materials & Spares*	*Finished goods*	*Materials & Spares*	*Finished goods*
No. of observations	11	11	8	8	7	7
a - coefficient	26.22	3.39	28.39	5.30	21.55	17.53
standard error	4.23	5.55	3.82	6.94	4.04	2.27
t - value	6.20	.61	7.43	0.76	5.33	7.71
b - coefficient	.0696	.0464	.0670	.0421	.0878	.0225
stanard error	.0032	.0027	.0079	.0079	.0105	.0030
t - value	21.72	17.10	8.48	5.35	8.35	7.52
R^2	.991	.985	.923	.827	.933	.919
F - Variance Ratio	471.57	292.50	71.96	28.65	69.77	56.50

1 to 10 and all the eleven years shows that the coefficient 'a' is not significantly different from zero. The R^2 in the last three groups of years is more than .9 and when analysis is confined to only 8 years R^2 is .827. This indicates that stocks of finished goods have moved over the period as a whole in constant ratio with the sales, despite the fact that in the first seven years there is evidence of economies of scale.

The results of regression, according to this model $I = a + bS$ in respect of all the inventories, were also examined and these have shown consistent evidence of economies of scale for inventories as a whole in this group. The intercept 'a' is found +ive and is significantly different from zero at 95% confidence in all the five groups of years. The R^2 is greater than .95. It means economies of scale in the holding of raw material inventories have offset the effect of higher holding of stocks in finished goods inventories during the last four years of the period under study.

Model II : The alternative theory to that of the linear model I is that inventories are a square-root function of sales/usage(i.e. $I = a + bS^{\frac{1}{2}}$). Regressions were run again for each of the two kinds of inventories in the same correlation as in the Model I and results are set out in Table 4.

Table 4 : Regression of Inventories to Usage : $I = a + bS^{\cdot 5}$

Parameters for Analysis	*1966-67 to 1976-77*		*1966-67 to 1973-74*		*1966-67 to 1972-73*	
	Materials & Spares	*Finished goods*	*Materials & Spares*	*Finished goods*	*Materials & Spares*	*Finished goods*
No. of observations	11	11	8	8	7	7
a - coefficient	−34.80	−67.83	−2.91	−24.14	−8.63	3.11
standard error	10.86	10.77	4.56	15.37	5.92	4.83
t - value	−3.21	−6.30	−0 64	1.57	−1.46	0.64
b - coefficient	4.5880	3.9487	2.9905	2.2871	3.3166	1.1614
standard error	.3508	.2723	.2199	0.5405	.3120	.1811
t - value	13.08	14.50	13.60	4.23	10.63	6.41
R^2	.975	.979	.969	.749	.958	.892
F - Variance Ratio	171.08	210.23	185.07	17.91	113.01	41.14

The value of intercept 'a' is found either −ive or not significantly different from zero at 95% confidence. The R^2 is quite high except in

the analysis of finished goods inventories for 8 years. The coefficient 'b' is +ive and is significantly different from zero. When mean value of 'S' was compared with the model value of $\frac{4a^2}{b^2}$, it was found that though the model responded to data, yet it failed to reflect the reality of life in the period as a whole. In the first seven and eight years the intercept 'a' for inventories of raw materials and finished goods is approaching zero. This fact together with reasonably high R^2 value, show that Model II in these periods is both valid and reflecting reality. The negative intercept 'a' and 'S' greater than $\frac{4a^2}{b^2}$ suggest that for the period as a whole the power of the exponent 'S' is more than .5 in both the categories of inventories. This calls for the need to examine the data according to the equation $I = \alpha S^{\beta}$

Model III : The Model $I = \alpha S^{\beta}$ indicates economies of scale, but these economies are not as great as those indicated by the square-root formula. Here it is expected that the exponent β would take value anywhere more than .5 and less than 1. Linear regressions for this model in five different groups of years were calculated in the logarithmic form $\text{Log } I = \text{Log}\alpha + \beta \text{ Log } S$. The results of regression for each of the two kind of inventories in the same correlation as in the previous two models are indicated in Table 5.

Table 5 : Regression of Inventories to Usage : Log I = Log α + β Log S

Parameters for Analysis	*1966-67 to 1976-77*		*1966-67 to 1973-74*		*1966-67 to 1972-73*	
	Materials & Spares	*Finished Goods*	*Materials & Spares*	*Finished Goods*	*Materials & Spares*	*Finished Goods*
No. of observations	11	11	8	8	7	7
β	.6453	.9029	.5528	.6594	.6002	.4289
standard error	.0323	.0737	.0423	.1397	.0537	0.0719
t - value	20.01	12.26	13.07	4.72	11.18	5.97
Log α	.18	—2.31	0.73	—0.74	0.46	.71
standard error	4.43	3.95	1.25	3.55	1.21	1.04
t - value	0.04	—.59	.58	—0.21	0.38	0.68
R^2	.989	.971	.966	0.788	.962	.877
F - Variance Ratio	400.20	150.29	170.90	22.29	125.06	35.61

The β value for inventories of materials and spares in respect of five groups of years varied between .55 and .64. In this category of inventory R^2 for the fit is very good. These give a consistent evidence of economies of scale. The 6 values of β indicate the slope of the log-log line and it means that each unit one moves the usage/sales to the right, the inventory line rises by 0.6 unit. Apparently the relative economies indicated by the difference between .60 and .50 (slope in case of square-root relation) may not seem to be very significant, but the rupee value involved in the undertaking is very large. A small change in the β coefficient in Model III represents a large change in the value of inventories in relation to sales. For the entire period of eleven years β value is .645 and is significantly different from both zero and .5 because table 't' value at 95 percent confidence is more than the actual 't' value. This shows that over the period as a whole there had been economies of scale, but not to the extent of square-root relationship. The results of the application of this model in respect of inventory component of crude materials and spares reinforces the conclusion drawn from Model I.

In finished goods the β value for the total period under study is .9029 and is significantly different from zero at 95% confidence. The application of further test shows that it is not significantly different from one. In the other group of years of 1 to 9 and 1 to 8 the β values respectively are .857 and .659 and are significantly different from zero at 95% confidence. In these two cases values of R^2 are low at .880 and .788. In the case of first seven years the β value is .4289 and significantly different from zero but not different from .5 at 95% confidence. R^2 is .877. These facts (when taken into account alongwith the results of other analysis) show that during first seven years there is strong evidence of economies of scale, but in the subsequent years the inventories of finished goods have increased substantially. This on the whole has made the finished goods inventories to move in constant ratio with sales despite the significant economies of scale in the first seven years. This conclusion is also supported by the results of the application of Model I.

Excess Holdings

The application of the models gives evidence of some rationalisation In the management of inventories of raw materials, but not to the extent

shown by square root relationship. The models, however, did not assist in assessing the excess inventories existing on any date. An approximate idea of the excess holdings can be formed through analysis of growth rates. The classical theory tells that the optimum value of order (the one that minimises the total procurement and stock holdings costs) is given by $I = K\ S^{\frac{1}{2}}$ where K is the policy variable taking care of the balance between frequent orders and high stocks. It means that *ceteris paribus*, if annual consumption or sales rise to a new constant level, say from 1000 to 2000, the economic order quantity will rise by 41%—strictly speaking by under-root of 2 which is nearly 1.4142. In a study of the eleven years if it is assumed that safety and policy variable stocks have not changed over time and also initial stocks were normal then inventories should under ideal conditions grow as square-root of sales/usage. In that case the unity growth rate of inventories, say 'g', will be obtained by $\left(\sqrt{1+g_s} - 1 \right)$ where g_s is the unity compound growth rate of sales or of usage, obtained through regression against time. With the help of ideal growth rate of inventories it is easy to ascertain the excess inventories in any terminal year. The excess percentage of inventories in the terminal year, say the eleventh year of the period, will be given by

$$\frac{I_{11} - \hat{I}_{11}}{I_{11}} \times 100 \qquad \ldots\ldots(1)$$

where I_{11} is the actual inventories of the terminal year; $\hat{I}_{11}$ stands for inventories under ideal conditions of square root relationship. It can be obtained by $I_o \times (1+g)^{11}$ where 'g' is the unity growth rate of inventories under ideal conditions of square root relation with sales/usage and I_o is the actual stocks in the initial year.

Substituting in (1) the value of $\hat{I}_{11}$, we get

$$\text{Percentage of Excess stocks in terminal year} = \frac{I_{11} - I_o\ (1+g)^{11}}{I_{11}} \times 100$$

$$\text{or} \quad \left\{ 1 - \frac{I_o (1+g)^{11}}{I_{11}} \right\} \times 100 \qquad \ldots\ldots(2)$$

If excess holdings in 10th year are to be calculated, then growth rate over the decade will be worked out and inventories of that year, i.e., I_{10} will be put. In that way excess stocks in any year can be estimated.

For the above calculations the inventories in the initial year are assumed to be normal. If stocks in the beginning of the period under study are found to be excessive to requirement, then the above formula (2) will give an under-estimate of excess inventories. The various case studies made by the Committees on Inventories Control of Bureau of Public Enterprises and Committees on Public Undertakings show that in the initial year for want of experience, most of the public undertakings were guided by the advice of foreign consultants on the purchase of stocks and spares. This, in a large number of cases, resulted in the piling of stocks which could not be used for many years. The stocks surplus to the needs of initial years should normally lead to relatively-less purchases in subsequent years and in these circumstances it should be easier to adhere to the square-root relationship. It is also assumed that during the period of eleven years safety and policy variables did not change. In fact with the economic and technological development during the period, the risk of uncertainity in availability of raw materials and spares has been relatively reduced in later years. On this account also, therefore, the undertakings should carry comparatively less stocks. As such in these circumstances by estimation of the excess inventories on the assumption of no change in safety and policy variables, there is no over-estimate. In any case the excess of inventories estimated through above methodology must be interpreted in proper perspective. It is calculated through a technical relationship and is not based on actual behaviour of inventories *vis-a-vis* usage/sales. The behaviour pattern can be studied more meaningfully through application of models. The models help in examination of the extent of economies of scale and not in assessing the level of excess stocks existing on any date. Though the growth rate in methodology is simple to apply and gives an approximate idea about savings the public undertakings can make in holding of inventories, yet its inherent difficulty of being static in nature must not be forgotten. Moreover, the above methodology of the estimation of growth rate of inventories under ideal conditions derived from rate of increase in sales, will not reveal the confidence level of the strength of association between two variables, as the models do. In view of these limitations the excess percentage of stocks in the terminal year generated by analysis of growth rates should not be viewed with arithmetic accuracy as the figures might seem to convey. It is only an approximate excess under laboratory conditions.

Analysis of Growth Rates : During the first seven years value of produce

and inventories grew at 21.5 and 11.06 percent respectively. If inventories in that period had moved in the square-root relationship of sales, the growth rate would have been 100 $\left(\sqrt{1.215} - 1\right)$, i.e., 10.2 percent. The actual growth rate of 11.06 is marginally different from the 10.2 percent rate. Over the eleven years, the value of produce grew at a compound rate of 28.46% per annum (obtained through regression) and the inventories increased at 22.3 percent. If the square-root relationship had been adhered to, the growth rate of inventories would have been 13.34% rather than 22.3%. It seems after oil crisis in 1973-74, inventories increased at a much faster rate as compared to that of the first seven years of the period under study. At the end of 11th year petroleum enterprises had excess stocks of 44.4 percent as compared to what it should have been under the optimum conditions determined by square-root relationship. Thus out of total holdings of Rs. 433 crores nearly Rs. 197 crores are excess to the working under optimal conditions.

If the inventories of crude materials and spares had moved in square-root relationship with their usage, the rate of growth would have been 11.1 over first eight years, and 13.7 over the first nine years as against the actual growth rates of 12.72 and 15.43 percent. This also indicates that in first eight years inventories moved quite closely to the square-root of consumption and thereafter some signs of deterioration are seen. If the entire period of eleven years is taken into account the inventories of crude materials and spares under square-root relationship should have grown at 15.26% whereas actual rate of growth was 19.97%. This shows the importance of perpetual control of inventories. Unless a constant watch over inventories is kept it is not possible to have optimum use of funds invested in stocks. The excess inventories of raw materials and spares in the terminal year of the period under study as compared to those required under ideal conditions of square-root relationship are 28.88 percent, i.e., Rs. 69 crores out of total holdings of Rs. 237.6 crores in 1976-77.

The stocks of finished goods in the first seven years of study increased at a compound growth rate of 8.9 percent whereas sales during the period grew at 21.5 percent. By any standard the rate of growth in finished goods inventories was extremely low and it was lower than even the rate of growth under conditions of square-root relationship which works out at 10.2%. In subsequent years the stocks of finished goods

increased at a much faster rate. During eight years, the value of produce increased marginally from 21.5 (in first seven years) to 21.79% and inventories of finished goods shot up to 13.93% as compared to 8.9% and crossing the growth rate under square-root relationship conditions. If the entire period of eleven years is studied together, then the growth rate under ideal conditions of management control should have been 13.34%, whereas it actually was 24.66%. On that basis excess holding of finished goods works out at 47.14% i.e., about Rs. 90 crores out of Rs. 190 crores stocks of finished goods.

In-depth Studies

The Committees on Inventory Control of Bureau of Public Enterprises enquired into the levels of inventories and methods of control in ONGC and Barauni Refinery. The Committee on Public Undertakings (Fifth Lok Sabha) reviewed the control system of ONGC in their Sixteenth Report. The Indian Oil Company is the other undertaking which was studied by the Committee on Public Undertakings (Fifth Lok Sabha—52nd Report). The inventory position is further reviewed every year by Bureau of Public Enterprises in their Annual Report of Central Government Undertakings. These studies give evidence of excess inventories of spares. In the initial years this group of enterprises purchased large stocks of spares on the advice of foreign collaborators and with a view to utilising credit facilities offered by various countries. As a result, despite disposal of surplus stores every year, the undertakings still had excessive inventories. On the basis of norms of stock holdings recommended by Committees on Inventory Control, ONGC and Barauni Refinery had between 30 to 33 percent excess inventories in different years of study.

Analysis of growth rates indicated an overall excess of 44 percent whereas two case studies revealed figures of 30 and 33 percent. The experience of other countries show that a reduction of stocks between 20 to 25 percent in manufacturing undertakings is within easy reach of management through modern inventory techniques. This will release nearly Rs. 100 crores of capital for active use, apart from saving 10 to 15 percent of carrying cost of stocks every year as revealed by case studies of Bureau of Public Enterprises.

Conclusions

To study the behaviour of inventories of 11 Central Government Petroleum Enterprises over 1966-67 to 1976-77 six tests were applied. These related to : (i) inventory turnover ratios; (ii) trends in investment of inventories—absolute and in terms of period of usage/sales; (iii) comparison of level of holding with similar undertakings under different management styles; (iv) regression analysis according to three preconceived models; (v) analysis of growth rates; and (vi) corroborative evidence from in-depth study at micro level. The results of investigations are consistent in respect of the following conclusions :

i) The evidence here indicates that the undertakings of petroleum group had taken advantage of economies of scale in holding inventories, but these are not as great as those indicated by the square root formula evolved by management scientists. As a result we hold stocks more than what are required for efficient production flow. Our estimate indicates scope of reduction of inventories of about 44 percent, i.e., of Rs. 197 crores out of total average stocks of Rs. 443 crores in last year of the period under study.

ii) The two case studies show that the undertakings had in the initial years purchased excess inventories of spares partly on the advice of foreign collaborators and partly with a view to utilising credit facilities offered by various countries. As a result, despite disposal of surplus stores every year, the undertaking had still carried some excessive inventories. According to one study the excess holdings were of the order of 30% of the stocks on 31st March 1969.

iii) Keeping in view the experience of other countries a reduction of stocks between 20 to 25 percent is within easy reach of management through modern inventory techniques. This will release about Rs. 100 crores of capital for active use apart from savings in carrying cost of stocks every year.

iv) If judged from the turns ratios alone, the inventory performance in this group of enterprises is quite good as compared to the companies in U.S.A. The sales to inventory turns ratio for 37 petroleum integrated corporations of America had a range of 11.7 to 3.7

upper and lower quartile, the medium being 6.3. This ratio in the petroleum group of Central Government public sector undertakings during the period under study varied between 6 and 10. The highest achieved rate was 9.96 in 1976-77, the mode being 9.

v) The turnover ratio of raw materials consumed and their average inventories has shown on the whole progressive improvement. Considerable economies of scale were exercised upto the first nine years of the period under study. In the last two years of the study there had been substantial increase in inventories. On the whole the excess inventories over actual holdings at the end of 11th year as compared to those required under ideal conditions of square-root relationship are in the neighbourhood of 29%, i.e., Rs. 69 crores out of Rs. 238 crores. In the first eight years this component of inventories grew at the rate of 12.72% whereas under ideal conditions of management scientist it should have increased at the rate of 11.1%.

vi) Keeping in view the fact that work-in-process inventories are dependent on production cycle and pattern of sales, the holding in this category appeared to be satisfactory. During the period under study it had never exceeded 1.8 days of cost of sales and mode was 0.9 day.

vii) The inventories of finished goods in the first seven years of the said period had grown at a rate less than even the growth rate under conditions of square-root relationship. It was possible to have a very low growth rate of finished goods inventories in the first seven years due to large holdings of stocks in the base years. Subsequently in the last four years after fuel crisis considerations of economies of scale in the holding of inventories were less important than those of demand shrinkage and chances of break in regular supply. As a result, inventories were increased substantially. On a broad basis the undertakings in the 11th year carried excess inventories around 47% (Rs. 90 crores) of the actual stocks (Rs. 190 crores) as compared to the requirements under ideal conditions.

viii) The application of models to inventories of raw materials and finished goods show that the time series data has responded to

the model of square-root relationship in the first seven and eight years of the period under study. The other evidence brings out that the movement of inventories in square-root relationship with their usage in earlier years had been possible due to heavy build-up of stocks in initial years. If all the eleven years are considered together, then raw materials have moved at a rate slightly higher than under-root of the usage and finished goods at constant ratio with sales.

ix) During the period under survey when Inventory models were given wide currency some rationalisation took place in inventory policy, and substantial advantages of economies of scale were taken. A constant vigilance on the levels of inventories is necessary to maintain them at an optimum level.

x) The evidence here on the whole does not refute but rather supports the generally held hypothesis that level of inventories is higher than what is required for efficient production and service flow. □

Assessment Centres

Narendra K. Sethi* & Philip Matarese**

Concept Definition

What is an assessment centre? What does it do? What are its functions? These are just several questions being asked today by more and more people in the business world. Simply put, an assessment centre is a "place where assessments are made ".[1] In a recent issue of their publication, *Training and Development Journal*, (March 1972) the American Society for Training and Development defined assessment centres in the following manner[2] :

> An Assessment Centre is a multiple assessment of several individuals performed simultaneously by a group of trained evaluators using a variety of group and individual exercises.

Walter S. Wilkstrom, writing in the *Conference Board Record*, also has considered and gives attention to this relatively-new technique and reports[3] :

> Assessments...are the pooled judgments of several specially trained managers who use a variety of criteria to evaluate a man's performance as he goes through several different test situations. Usually some paper-and-pencil tests are also used, and an intensive interview is a normal part of the assessment procedure. It is this matter of multiple judgments based upon observations of performance in several situations that is the crux of the assessment centre method.

Richard Steiner, in his article, "New Use for Assessment Centres—

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1. Walter S. Wilkstrom, "Assessing Managerial Talent", *The Conference Board Record*, March, 1967, p. 39.
2. *Training and Development Journal*, "An Assessment Centre Program for Multi-Organizational Use", American Society for Training and Development, March, 1972, p. 6.
3. Wilkstrom, *Op. Cit.*, p. 39.

Training Evaluation" evaluates and defines for us what he considers an assessment centre to be, and the role it can perform in the organisation. He writes[4] :

> As originally conceived, an assessment centre is a multi-functional mechanism.
>
> First, it can aid an organisation in the critical selection process by providing a mechanism for objectively identifying and determining immediate management potential.....
>
> Second, the centre serves as a means for identifying and developing individualised executive improvement strategies...
>
> Third, the assessment centre can be thought of as a training vehicle. Research indicates that participants view the assessment process as a learning experience...
>
> Fourth, the assessment centre can have a positive influence on morale, job expectations, and motivation. Candidates view the centre as a means for fairly and objectively evaluating their worth and ability to perform...
>
> Finally, the centre can be used as a highly accurate means for evaluating executive development, or other types of training programmes.

It has been our intent in this section not to deal with the specific procedures and tasks that make up the programme of an assessment centre. Such specifics will be dealt with later. For now, our goal in this introduction has been to acquaint the reader with a basic overview of the assessment technique regarding its nature, function, and purpose through concept definition. As one might expect, much confusion had arisen regarding this relatively-new methodology and the precise nature and organisation of a typical assessment centre. Even the name is somewhat misleading. For example, the assessment centre is not a particular place nor a particular location as might be implied

4. Richard Steiner, "New Use for Assessment Centres – Training Evaluation", *Personnel Journal*, April, 1975, pp. 236-37.

but rather, it is a technique for employee selection, development, evaluation and training, occuring possibly in many different locations.

Allen I. Kraut has clarified the concept in his article entitled, "New Frontiers for Assessment Centres" wherein he provides us with the comparisons as illustrated in Chart I.

CHART I

What an Assessment Centre Is ..

The Task Force on Development of Assessment Centre Standards has recommended that a programme be considered an assessment centre only if it meets the following minimum requirements :

1. Multiple assessment techniques must be used. At least one of these techniques must be a simulation *(A simulation* is an exercise or technique designed to elicit behaviours related to dimensions of performance on the job by requiring the participant to respond behaviourally to situational stimuli. The stimuli present in a simulation parallel or resemble stimuli in the work situation.)
2. Multiple assessors must be used. These assessors must receive training prior to participating in a centre.
3. Judgments resulting in an outcome (that is, recommendation for promotion, specific training, or development) must be based on pooling information from assessors and techniques.
4. An overall evaluation of behaviour must be made by assessors at a separate time from observation or behaviour.
5. Simulation exercises are used. These exercises are developed to tap a variety of predetermined behaviours and have been pretested prior to use to ensure that the techniques provide reliable, objective, and relevant behavioural information for the organisation in question.
6. The dimensions, attributes, characteristics or qualities evaluated by the assessment centre are determined by an analysis of relevant job behaviours.
7. The techniques used in the assessment centre are designed to provide information that is used in evaluating the dimensions, attributes, or qualities previously determined.

and Is Not

The following activities do not constitute an assessment centre :

1. Panel interviews or a series of sequential interviews as the sole technique.
2. Reliance on a specific technique (regardless of whether a simulation or not) as the eole basis for evaluation.
3. Using only a test battery composed of a number of pencil and paper measures, regardless of whether judgments are made by a statistical or judgmental pooling of scores.
4. Single assessor assessment (measurement by one individual using a variety of techniques such as pencil and paper tests, interviews, personality measures, or simulations).
5. Use of several simulations with more than one assessor where there is no pooling of data (that is, each assessor prepares a report on performance in an exercise, and individual, unintegrated reports are used as the final products of the centre).
6. A physical location labelled as an "assessment centre" does not conform to the requirements noted above.

Source : Allen I. Kraut, "New Frontiers for Assessment Centres". *Personnel*, July-August, 1976, pp. 32-33

Historical Development

> The assessment centre technique was pioneered by Dr. Douglas Bray and his associates at American Telephone and Telegraph Company in the mid 1950's.[5]

This statement by Allen I. Kraut, Personnel Research Manager at IBM, writing in *Personnel Journal*, is indicative of what many people believe to be the origin of the assessment centre methodology in use today. Careful examination of this technique reveals that its roots lie somewhat further into the past. As early as World War I, the Germans were supposedly using this concept for the selection of intelligence agents.[6] The Germans, however, were not alone. In the US, some individuals were aware and experimenting with the assessment centre approach. In a recent issue of *Public Personnel Management*, Donald S. Macrae provides us with the following[7] :

> Although the first reported application of assessment centres was by German Military Psychologists in selecting officers during World War I, the centre approach was probably first tried in the US private sector by Professor Henry Murray of Harvard University in his research on personality in the 1930's.

Using similar techniques on his students, Professor Murray's work and findings are contained and still available for observation in his book, *Explorations in Personality*.[8]

Renewed attention and concern was given to the assessment centres as the world approached and became involved with international conflict. The World War II saw increased use of the assessment centre for selection of officer candidates by both Germany and Great Britain. The United States Government also became interested in this evaluation and

5. Allen I, Kraut, "A Hard Look at Management Assessment Centres and Their Future," *Personnel Journal*, May, 1972, p. 317.
6. Dennis P. Slevin, "The Assessment Centre : Breakthrough in Management Appraisal and Development." *Personnel Journal*, April 1972, p. 256.
7. Donald S. Macrae, "..... An Academic Laboratory Report," *Public Personnel Management*, September-October, 1974, p. 367.
8. *Training and Development Journal, Op. Cit.*, p. 6.

selection tool. In *The Conference Board Record,* Wilkstrom reports[9] :

> In the United States, the World War II office of Strategic Services used assessments to pick men for clandestine assignments behind enemy lines.

The first industrial applications of the assessment centre occurred in the 1950's at AT&T, under the leadership of Dr. Douglas Bray.[10] In an article appearing in the *Journal of Applied Psychology,* Dr. Bray and Richard J. Campbell describe the beginnings of the programme at AT&T and what they had hoped to achieve. They write[11] :

> The assessment centre received its first industrial application when it was introduced into the Bell System in 1956 as a major research method of the Management Progress Study. Two years later, in 1958, an assessment centre was opened in the Michigan Bell Telephone Company for the appraisal of candidates for promotion to management from vocational occupations. The results of this first operational assessment centre were deemed so useful by line managers that the assessment-centre method spread widely through the Bell System until over 50 assessment centres were established in the Bell System Companies processing approximately 8,000 men and women each year who are candidates for management positions.

Due mainly to the success of the centres at AT&T and to the weaknesses and shortcomings of traditional testing and employee evaluations, the assessment centre idea has come to spread the use and acceptance in both the private and public sector of our country. The *Training and Development Journal* reports that in 1969, 13 organisations had developed and put into use an assessment programme.[12] Companies such as IBM, General Electric, J. C. Penney Co., Standard Oil and Sears, had become assessment practitioners.[13] By 1972, the

9. Wilkstrom, *Op. Cit.*, p. 39.
10. *Training and Development Journal, Op. Cit.*, p. 6.
11. Douglas W. Bray and Richard, J. Campbell, "Selection of Salesmen by Means of an Assessment Centre", *Journal of Applied Psychology*, 1968, Volume 52, No. I, p. 36.
12. *Training and Development Journal, Op. Cit.*, p. 6.
13. Slevin, *Op. Cit.*, p. 256.

number of assessment users had swelled to over 100. In his article, "... An Academic Laboratory Report" Macrae writes[14]:

> The Great Lakes Assessment Council (a consortium of States of Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin, and the cities of Chicago, Detroit, Milwaukee, Minneapolis and Toledo) funded by an Inter-governmental Personnel Act (IPA) grant, studied assessment centres and published a report in November 1972. The results of a year's research and study of assessment centres in the US indicated that over 100 different organisations, mostly private, had employed the assessment centre approach and had found it to be a most effective assessment technique.

We thus can see that the history of assessment centres is rather short, dating from approximately World War I. Its use in the private sector has been recognised only for the past 20 years. The impact it has made, and most assuredly will continue to make in the future, may prove it to be one of the most significant methods for evaluation, development, and training of employees ever devised.

Deficiencies of Traditional Methodologies : Comparison to Assessment Centres

Traditional methods of testing for employee appraisal, training or development has been part of the domain of the psychologist. With tools and techniques like psychological testing, interviews, ink blot intrepretations, human analysis and biographical sketches, he has been charged with the responsibility and duty to attempt evaluation and assessment of employee potential and possibie promotions. Until recently, his word and domain were sacrosanct. More and more, however, people have become aware of the limited effectiveness of these approaches to assessment. Dennis P. Slevin comments in his article "The Assessment Centre : Breakthrough in Management Appraisal and Development" on the effectiveness of the psychological testing[15] :

14. Macrae, *Op. Cit.*, p. 367.
15. Slevin, *Op. Cit.*, p. 255.

> "Thousands of psychological tests have been developed for the specific evaluation of personality traits and mental aptitudes, but they tend to be rifle shot approaches that evaluate some narrow aspect of executive potential."

Cabot L. Jaffee, Personnel Research Analyst at AT&T, has given considerable attention to the nature and use of psychological techniques. According to his findings published in *Personnel Journal*, he believes that there is a definite distinction and varying applicability between the business world and educational institutions. He writes[16] :

> It does appear that there are certain basic differences between industry and schools or clinics when one considers the role of the psychologist and the test. First, the information gathered about a man in industry is relative to selection for promotion, special assignment or some other special skill determination. In schools or clinics, the information answers-questions concerned with potential adjustment, intelligence and emotional problem areas . . . .
>
> A second major difference between testing in the two areas lie in the use to be made of the information. In schools and clinics, the information the tests provide is invariably used in a developmental way, that is the information is fed back to people interested in modifying the individual's behaviour for the better. In industry, on the other hand, the tests are used, for the most part, to accept or reject a man for a particular assignment, many times for some very tenuous reasons.

What is objectionable to Mr. Jaffee and other researchers is that the same psychological testing techniques are used by the psychologists in a wide and varying range of situations and environments to examine and evaluate individuals, for diverse reasons, uses, goals and purposes. Such practices and procedures are both highly questionable and thus unacceptable to Jaffee. He continues[17] :

16. Cabot L. Jaffee, "Managerial Assessment : Professional or Managerial Prerogative ?" *Personnel Journal*, 1966, Volume 45, p. 162.
17. *Ibid.*, p. 162.

> .....There may be basic difference between testing in industry and testing in other traditional psychological domains. They have, however, apparently been equated on an almost one to one basis in many people's minds—what the psychologist can do in the clinic he can do in the factory. In regard to this point, the psychologist has, in many cases, been remiss in his duties by being all too willing to use the same technique in both types of setting.

What are some of the other traditional problems that make the assessment centre technique so appealing today? In a recent article in *Personnel*, William C. Byham and Regina Penetecost compare the assessment centre approach to traditional schemes and tell us some of their findings[18] :

> Studies made of thousands of employees assessed during the last few years indicate that the assessment centre method is much more accurate than traditional appraisal procedures.

Their rejection of traditional means is summarised in the following remarks[19] :

> Appraisals are often distorted by supervisors who try to achieve short-range salary advantages for subordinates, and by the differences in supervisors' own values and abilities. In the assessment centre method, accurancy is assured because standardised exercises provide an opportunity for assessors to evaluate candidates under constant conditions, which make possible comparative judgments.

Walter S. Wilkstrom in the *Conference Board Record* views the assessment centre technique particularly useful for two common problems that traditional analysis has had limited success[20] :

> For one thing, the work of a craftsman is quite different from

18. William C. Byham and Regina Penetecost, "The Assessment Centre : Identifying Tomorrow's Managers," *Personnel*, September-October, 1970, p. 17.
19. Ibid , pp. 17-8.
20. Wilkstrom, *Op. Cit.*, pp. 39-40.

> that of a manager. Yet, a manager trying to select a future foreman has to go by job performance as a craftsman . . . . Another problem is that the manager probably can consider only a very few of the men who should be under consideration. Thus he may have only a limited idea of the range of talent that is available. An assessment centre, on the other hand, can assess all the men who seem to have management potential . . . .

The ineffectiveness of traditional methods to determine employee potential is an area discussed in *Business Week*. In an article entitled, "Where they make believe they're the boss," *Business Week* quotes Douglas Bray of AT&T[21] :

> With assesment, you can also find talent you might otherwise miss, says Bray, and an example from a pilot programme at the Autolite-Ford Div. of Ford Motor Co. tends to bear him out. One of the 12 middle-manager candidates, recalls James Anderson, the personnel-planning coordinator, was a man with no college training who had never worked in an office. "He had a time clock in his head and out-analysed most of the guys," says Anderson. "He'll probably get a promotion he would not have gotten if he hadn't gone through the exercises."

Another problem facing traditional means of evaluation has been legal in nature. Recent court rulings and legislation such as the Anti-Discrimination law, EEOC, and Affirmative action, etc., have worked to ban and eliminate many established testing techniques as discriminatory and thus illegal. If a procedure is not closely related to the job function, its validity and viability may be in question. Assessment centre methodology has been and continues to be accepted by legislative and governmental bodies as a legitmate selection technique. Donald S. Macrae comments[22] :

> Assessment labs offer a process which appears to be in compliance with the US Equal Opportunity Commission

21. *Business Week*, "Where they make believe they're the boss," August 28, 1971, p. 34.
22. Macrae, *Op. Cit.*, pp. 367-68.

> regulations. Lab designs are behaviour-based and provide simulations of job-related tasks. Content validity is easily demonstrated, provided the behaviours selected for observation are shown to be those required for job success. Reported experience with assessment labs in both industry and government feel that behavioural approaches to selection are fair and impartial.

The problem of accurately evaluating women employees is particularly acute. Douglas Bray discusses this problem and the use of assessment centre techniques as a solution[23]:

> It is very hard to convince managers who might take a woman on a transfer basis into a job usually thought of as "male" that she has the requisite ability. Even her own boss may be skeptical about advancing her, since the undemanding nature of many entry jobs for women does not allow a real demonstration of ability.

How does one determine and evaluate the management potential present in the group of female employees under these circumstances? How does one select and promote to be consistent with and satisfy affirmative action for example? According to Bray[24]:

> A thorough evaluation of potential is needed not only as a persuader, but to determine that the candidate actually does have the abilities needed.

The solution to this problem for Bray and for many other writers is the assessment centre technique.

As indicated in the paper, more and more organisations have begun to realise the effectiveness and benefits of the assessment centre approach when compared to the evaluation and testing tools of the past. In their article, "Assessment Centres—Further Assessment Needed," Wilson and

23. Douglas W. Bray, "The Assessment Centre : Opportunities for Woman", *Personnel*, September-October, 1971, p. 31.
24. *Ibid.*, p. 31.

Tatge comment on this growing acceptance, of assessment centres[25] :

> In some companies, line managers, staff professionals, and industrial psychologists are strongly enthusiastic about its advantages when compared with more traditional approaches. For example, William C. Byhan, formerly Manager of Selection, Appraisal and General Management Development of J.C. Penney (who has developed centres and surveyed others), states : "While the effectiveness of an assessment centre has not been proved beyond the shadow of a doubt, all the research, both published and unpublished, seems to indicate that the method has more validity than other existing methods.

Ginsburg and Silverman in their article, "The Leaders of Tomorrow : Tneir Identification and Development", provide us with a short summary of some important points[26] :

> Compared to other forms of personnel appraisal, this method [assessment centre] is seen to be more effective because all assessees (1) have an equal opportunity to display their talents, (2) are seen under similar conditions in relevant situations designed to bring out the particular skills and abilities needed for the position or positions for which they are being considered, and (3) are evaluated by a team of trained assessors, unbiased by past association, who are intimately familiar with the position requirements and the institutional climate.

Probably one of the most convincing arguments is from William C. Byham in one of his many articles on this topic. According to him, a company that uses the traditional techniques is putting itself in a weak and dependent position. He explains[27] :

> When a company uses psychological tests alone, or sends

25. James E. wilson and Walter Ashton Tatge, "Assessment Centres—Further Assessment Needed", *Personnel Journal*, March, 1973, p. 173.
26. Lee R. Ginsburg and Arnold Silverman, "The Leaders of Tommorrow : Their Identification and Development", *Personnel Journal*, September, 1972, p. 663.
27. William C. Byham, "Assessment Centre for Spotting Future Managers", *Harvard Business Review*, July-August, 1970, p. 155.

candidates to an outside psychologist for evaluation, it is in reality weakening itself because its executives are becoming dependent on others.

The assessment centre method not only improves the assessee but the assessor improves as well, and thus the entire company benefits.

Chart II illustrates assessment centre benefits by comparing it with other methods.

CHART II

Comparison of Assessment Centre Method with Typical Use of Panel Interviews and Testing

Assessment Centre	*Panel Interviews*	*Paper & Pencil Test*
Built around dimensions carefully defined through job analysis, and all dimensions are systematically covered.	While dimensions from research may be used, more often no list is used or an inadequate list is used. No real attempt to cover all of the dimensions is made in the interview due to the usual lack of structure.	Tests may be selected by job analysis but tests only attempt to predict certain of the dimensions. For example, tests are poor at determining interpersonal dimensions.
Dimensions are agreed upon by management before use. This creates an acceptance and understanding of them.	Usually not the case	Usually not the case.
The involvement of higher-level manager in the selection of assessment centre dimensions and as assessors allows them to make effective use of assessment centre reports and to believe in the results because they understand the system.	Membership of higher-level managers on interview panels often increase their distrust of the Panel Interview process as they feel it is unreliable. Thus they discount the results.	Unless a specific cut-off score is used as in Civil Service Examinations, the users of the test results seldom know how to integrate the test results with other performance data.
Multiple exercises are used. The participant can be observed in different situa-	Single exercise.	Tests may be slightly different depending on tests used but all generally

CHART II *(Contd.)*

Assessment Centre	*Panel Interviews*	*Paper & Pencil Tests*
tions : group and non-group; small and large group exercises that require preparation and those that do not; exercises where the participant is a subordinate, peer, supervisor; exercises requiring oral, written and other skills.		emphasise written and cognitive skills.
Uses multiple judgements (3 to 6 assessors) which increase accuracy and decrease bias.	Uses multiple judgments.	Quantitave score. Use of score may be judgmental.
Trained observers are used.	Participants in panel interviews are seldom trained and seldom have adequate time to plan the interview.	
Assessors usually do not know participants.	Interviewers usually do not know participants.	
Assessors are several levels above participants and thoroughly know the target-level job.	Interviewers are several levels above participants and thoroughly know the target-level job.	
Real behavirous observed.	What a participant says he would do or has done is determined. Follow-up of important areas possible.	Participants often say what they think will get a high score in nonability tests.
Formal method of recording observations used.	Usually no formal method of recording observations of behaviour or insights.	Formal method of collecting data used.
Large amount of data on participant obtained.	Small amount.	Small amount.
Procedure delays final decision until all information about participant is obtained.	Research indicates that interviewers quickly jump to a decision and their subsequent questions are often an attempt to reinforce the first decision.	Highly quantitative.

CHART II *(Contd.)*

Assessment Centre	*Panel Interviews*	*Paper & Pencil Tests*
Highly-structured programme producing quantitative results	Low in structure. Low in quantitative results.	Highly quantitative.
High reliability.	Low reliability.	High reliability.
Validities usually around 4 to 5.	Little known about validity.	Seldom above 3.
Technique flexible to various jobs.	Technique flexible to various jobs.	Less flexible because content validation for supervisory and managerial jobs is more difficult to achieve.
Relatively easy to establish content validity (job-relatedness).	Difficult to establish content validity (job-relatedness).	Difficult to establish content validity (job-relatedness).
Criterion-related validity research should be conducted.	Criterion-related validity research should be conducted.	Criterion-related validity research should be conducted.
Produces insights into development needs that can be benefical whether or not the participant is promoted.	Not usually the case	Not usually the case.
Process is understandable to participants, they see it as a fair means of evaluating all areas of management potential.	Participant evaluation of fairness depends on interviewers. Most interviewers feel interview covers only a portion of important management skills.	Often misunderstood, biases carried over from negative school experiences.

Source : William C. Byham and Carl Wettengel, "Assessment Centres For Supervisors and Managers...An Introduction and Overview," *Public Personnel Management,* September-October, 1974 , p. 359-60.

Assessment Centre

As previously stated, the assessment centre method is not a place but a technique for evaluation, selection, development and training of company personnel. Under common operating procedures, a dozen individuals or assessees undergo a battery of simulated, job-related exercises over a

period of 3½ days. With one assessor for every two assessees, the entire programme normally lasts five days. After the assessees or candidates finish their tasks and leave, the remaining time is spent by the assessor in their evaluation and report preparation regarding individuals examined. At this point the following happens. William C. Byham and Carl Wettengel describe the typical flow of events[28] :

> After the centre, the participants return to their jobs while the assessors spend from one to two and one half hours discussing individual observations of each participant .. Considering all the observations of behaviour during the centre, assessors eventually agree on an evaluation of the participants' strengths and weaknesses relative to each of the dimensions sought A written report of the centre results is prepared by the centre administrator and is distributed to the participant and/or higher level management.

To better develop the typical assessment centre and its activities, let us see how a typical centre might operate the organisation, and the various functions that are required. *Harvard Business Review* provides us with what one could consider a typical assessment cycle to contain based on the programme of the J.C. Penney Company.

While this approach is typical of most assessed centre operations, variations do exist. The Wolverine Tube Division of Universal Oil Products, Allen Park, Michigan, for example, has developed an abbreviated approach. *The Society for Advance Management Journal* reports that Wolverine Tube Company had "developed and validated a one-day assessment centre, thereby reducing considerably the length of time necessary to assess 12 people".[29] Let us now view in greater detail the important aspects of the assessment approach.

A. KEY DIMENSIONS

The first important step and consideration of any evaluation, training or selection programme is the determination of specific qualities or

28. William C. Byham and Carl Wettengel, "Assessment Centres for Supervisors and Managers..... .. ...An Introduction and Overview", Public Personnel Management, September-October, 1974, pp. 353-54.

characteristic abilities required for satisfactory performance. Ann Howard, Director of Research at L. F. McManus Co., Worcester, Mass., identified fifteen management qualities upon which an individual should be critiqued[30]. Because of the growing interest in this field and possible lack of uniformity, and because "many lists of management traits, abilities, and characteristics are available,"[31] the American Management Association decided to direct attention into this area and develop an assessment centre programme, generalised and applicable to many varied business situations. According to John H. McConnell, writing in *Personnel*, the AMA listed twelve "Management traits, abilities, and characteristics"[32] they consider important and are as follows[33] :

Functional ability : Existing successfully in one's environment.

Planning : Developing a course of action to achieve an objective.

Organising : Structuring or arranging resources to accomplish the objective of a plan.

Controlling : Maintaining adherence to a plan, modifying it if necessary, to achieve the desired result.

Oral communication : Transferring a thought from one person to another by speech, adjusting to audience reaction.

Written communication : Transferring a thought from one person to another by writing, without the possibility of response to audience reaction,

Company orientation : Identifying the organisation's goals and values as complementing one's own.

Leadership : Getting people to work toward reaching an objective.

Decision making : Consciously weighing and selecting one or two or more alternatives.

29. *Society for Advanced Management Journal*, "The Assessment Centre Technique", October, 1973, p. 27.
30. Ann Howard, "An Assessment of Assessment Centres", *Academy of Management Journal* Volume 17, No. 1, March, 1974, p. 117.
31. John H. McConnel, "The Assessment Centre : A Flexible Program for Supervisors", *Personnel*, September-October, 1971, p. 36.
32. *Ibid.*, p. 36.
33. *Ibid.*, p. 36.

Creativity : Developing alternate solutions to problems.

Initiative : Introducing one's own thought or action into a situation.

Flexibility : Adjusting to changing internal and external conditions, both personal and impersonal.

Once the critical dimensions for assessment have been determined, the appropriate measurements and testing devices or exercises can be developed to evaluate and select management potential.

B. SELECTION TECHNIQUES, DEVICES AND EXERCISES

With the desired managerial abilities and strengths in mind, appropriate exercises or tests can be developed and implemented to 'tap' or determine what and where potential might lay. Chart No. III is typical of the assessment centre exercises.

In the report, "The Use of the Assessment Centre in a Government Agency's Management Development Program" (June 29, 1972), various segments of the Metropolitan Transit Authority Assessment Programme are discussed, which is based on the American Management Association Assessment Centre Programme[34] :

> The eight Management Simulation Workshop exercises are designed to provide a method of clearly observing and evaluating performance in all 12 of the supervisory management abilities. These exercises, therefore, reflect typical problems and situations encountered by managers. The workshop exercises are :
>
> An *Interview* based on a background information form completed by each participant.
>
> A *Management Questionnaire* of ten questions concerning supervisory problems.

34. "The Use of the Assessment Centre In a Governmental Agency's Management Development Program, "The Metropolitan Transit Authority of New York City, June 29, 1972, pp. 4-5 (Unpublished).

An *In-basket* of supervisory mail handled by the participant in the role of a supervisor and followed by a role-played interview with a superior.

CHART III

Description of Exercises

Assigned Role Group Discussion
In this leaderless group discussion, participants, acting as a city council of a hypothetical city, must allocate a one-million-dollar federal grant in the time allotted or make other judgments on the varying proposals offered. Each participant is assigned a point of view to sell to the other team members and is provided with a choice of projects to back and the opportunity to bargain and trade off projects for support.

Non-assigned Role Group Discussion
This exercise is a cooperative, leaderless group discussion in which four short case studies dealing with problems faced by executives working in state government agencies are presented to a group of six participants. The participants act as consultants who must make group recommendations on each of the problems. Assessors observe the participant's role in the group and the handling of the content of the discussion.

In-basket Exercise
Problems that challenge middle and upper-level executives in State government are simulated in the in-basket exercise. These include relationships with departmental superiors, subordinates and peers, representatives of other departments, representatives of executive and legislative branches, the public, and the news media. Taking over a new job, the participant must deal with memos, letters, policies, bills, etc., found in the in-basket. After the in-basket has been completed, the participant is interviewed by the assessor concerning his/her handling of the various in-basket items.

Speech and Writing Exercises
Each participant is given a written, narrative description of a policy, event, situation, etc. and three specific situational problems related to the narrative, each requiring a written response. The participant is also required to make a formal oral presentation, based upon the background narrative description, before a simulated news conference attended by the Capital Press Corps and interested government officials and citizens (assessors).

Analysis Problem
The analysis problem is an individual analysis exercise. The participant is given a considerable amount of data regarding a state agency's field operations, which he/she must analyze and about which he/she must make a number of management recommendations. The exercise is designed to elicit behaviors related to various dimensions of managerial effectiveness. The primary area of behaviour evaluated in this exercise is the ability to sift through data and find pertinent information to reach a logical and practical conclusion.

Paper and Pencil Tests
Three different commercially-available objectively scoreable tests are included in the assessment : a reading test used for self-development purposes, a reasoning ability test, and a personality test. The latter two are being used experimentally at present, and as with the reading test, are not made available during assessor discusions.

Source : William C. Byham and Carl Wettengel, "Assessment Centres for Supervisors and Managers, ... An Introduction and Overview", *Public Personnel Management*, September-October, 1974, p. 355.

A *Luncheon* meeting in a group of three participants with an assessor.

A *Film Case Discussion* involving an employee promotion.

A *Selection simulation* in which criteria for supervisory selection and success are reviewed.

A *Management decision game* having to do with running a small company and handling merger negotiations.

Participant's written evaluations of their own performance.

One might legitimately ask at this point how typical are these exercises and functions presented by the AMA. Joseph M. Bender did just this to find out just what was typical of assessment centres. After contacting 38 organisations employing assessment centre techniques, in the US and Canada, he put together a summary[35] as shown in Chart IV.

CHART IV

Primary Evaluation Devices Used by Companies Operating Assessment Centres

	Yes	*No*	*Not Checked*
In-basket exercises used	31	3	4
Business game exercises used	30	4	
Assigned roles	19	11	4
Non–assigned roles	20	12	2
Leaderless group discussion exercises used	31	0	3
Assigned roles	23	9	2
Non-assigned roles	23	9	2
Films used	5	29	
Video tapes used	15	19	
Psychological tests used	20	13	1
For the most part, assessment devices are locally produced	23	10	1
For the most part, assessment devices are purchased externally	9	24	1
Ann-depth background interview is given to assessees	22	12	

Source : Joseph M. Bender, "What 'is Typical' of Assessment Centres?", *Personnel*, July-August, 1973, p. 51.

35. Joseph M. Bender, "What is 'Typical' of Assessment Centres?", *Personnel*, July-August, 1973, p. 51.

We can see that there is indeed consistency of techniques among these user organisations. Strict adherence to predescribed principles or procedures, however, should be avoided. The approach or technique to be employed must depend on the particular circumstances, the personnel involved, and on a multitude of other variable factors. Customised or tailor-made procedures are usually necessary. Byham states that,[36]

> . . . there is no right or wrong way to structure a centre—the specific application must be designed to meet specific company needs and operating requirements. This flexibility is reflected particularly in the variety and combinations of exercises in centres. Each company chooses exercises that bring out the behaviour they desire to assess.

C. WHO IS TO BE ASSESSED?—CANDIDATE SELECTION

In a recent issue of the *Academy of Management Journal*, Ann Howard discusses this question of selection[37] :

> Typically, assessees are in their first management position or are being considered for management. Candidates for other jobs are rapidly being included in assessment programs. However, assessees are usually nominated by their supervisors to attend the centre. There is some contradiction in this, since a basic purpose is to find a better way of rating potential than reliance on the supervisor's judgment.

In a situation such as this, bias and favouritism can get in the selection process. The decision as to whether a subordinate is to go to assessment or not often lies solely with his superior which can be self-defeating. Byham comments[38] :

> One of the reasons for using the assessment centre technique in the first place is to overcome some of the prejudices and biases inherent in supervisory judgment; yet the super-

36. William C. Byham, *Op. Cit.*, p. 152.
37. Ann Howard, *Op. Cit.*, p. 119.
38. William C. Byham, *Op. Cit*, p. 155-56.

> visor is ordinarily made the sole judge of whether a person should be assessed.

Two alternative solutions to this problem have been suggested : 1 (let the employee decides himself if he wishes to attend assessment, or as Allen Kraut puts it, "invite candidates to nominate themselves to attend the assessment centres[39] ; " or 2) make assessment mandatory for everyone upon reaching a certain level in the organisation or for every promotion thereafter.[40]

As might be expected, significant costs are involved in these attempts to eliminate bias. Such additional cost will also have a limiting effect on the number of companies which can afford to install these safeguards. One last point to be considered and understood by any assessee selected for assessment is that success at the assessment does not mean immediate promotion or other mobility. Edwin B. Jelks, State Personnel Training Supervisor, Southern Bell, Atlanta, comments on this point[41] :

> Participation in the programme is strictly voluntary. Attendance at a centre does not guarantee or even imply immediate or future selection for a management position.

The assessment centre technique, if used properly, not only can help determine and select those with the most potential and probability of managerial success but also can help identify particular problems and provide insight for correction and elimination for those with weaknesses through appropriate training assistance. If properly organised, nobody should fail an assessment.

D. ASSESSOR SELECTION AND TRAINING

Ann Howard writes[42] :

> A typical assessment centre will have four to six assessors in anywhere from a 4:1 to 1:1 ratio to assessees . . .

39. Allen I. Kraut, *Op. Cit.*, p. 321.
40. William C. Byham, *Op. Cit.*, p 156.
41. Edwin B. Jelks, "The Assessment Centre," *Administrative Management*, October, 1971, p. 67.
42. Ann Howard, *Op. Cit.*, p. 119.

> Management members are usually two or three levels above the position for which the candidates are being assessed.

What criteria are necessary for assessor selection? The primary consideration should be the individual's track record or the history of past performance. Position in the organisation must also be considered. Assessors must necessarily come from the upper levels in the company in order to have greater insight into the functions and duties required of the position they are assessing and thus have a greater awareness of the characteristics an assessee should display. These are by no means the only considerations. Wilkstrom states[43] :

> Companies should seek assessors who seem to be perceptive in dealing with others, who seem able to establish rapport in talking with men and who have natural ability to understand what makes a man tick. Communications ability is required, both oral and written. Oral communication is important because the overall assessments are arrived at in conference with other assessors; reports of observations must be made clearly and concisely. The ability to write clearly is important for the many written reports of observations that will be required from a staff assessor during his term of service.

Similar to assessees, the assessor is also normally chosen to perform this function by his superior.[44] Similar prejudices, biases and other shortcomings may accompany this appointment to the staff.

Training normally consists of watching and doing the tasks and exercises that the assessee group must perform. Mrs. Howard writes[45] :

> They become familiar with the exercises by participating themselves, watching videotapes, or observing actual performances as non-voting members of the assessment team. The behavioural dimensions to be assessed are defined, and assessors are given practice and instruction in how to recognise these behaviours.

43. Walter S. Wilkstrom, *Op. Cit.*, p. 42.
44. William C. Byham, *Op. Cit.*, p. 156.
45. Ann Howard, *Op. Cit.*, p. 119.

The AMA multimedia Supervisory Management Course recognises this need for assessor training and lists various activities they consider prerequisite.[46]

CHART V

* Workbook programmed homework completed prior to each of four training sessions, covering the concepts and preparation necessary
* Role playing—to provide experience and practice with the various components of the assessment workshop
* Audio tapes—of actual assessor reports, to demonstrate the techniques used
* Simulation exercises—to provide experience in the workshop group exercises
* Programmed 16 mm film—providing interaction in the learning of observational techniques
* 16 mm training films—covering the visual parts of the assessment programme

A leader's guidebook provided for the assessment programme chairman, who is responsible for carrying out the assessor's training course

Source : John H. McConnell, "The Assessment Centre", *Personnel*, September-October, 1971, p. 38.

If an assessor is to be effective and perform his necessary duties well, adequate training and sound understanding of all aspects of the Assessment Centre is a prerequisite to his success.

Costs

Gino's Inc., a fast food organisation estimates that a one-week assessment of 12 individuals costs them between $5000 to $6000.[47] AT&T estimates, assessment cost to be approximately $500 per candidate.[48] IBM estimates its cost for 12 assessees to be $5000.[49] One might consider and include the expense of time lost from job for assessee and assessor alike. The Metropolitan Transit Authority of New York City (MTA) determines expenditures for its assessment programme in the following manner[50] :

46. John H. McConnell, *Op. Cit.*, p. 38.
47. Kristin Anundsen, "An Assessment Centre at Work", *Personnel*, March-April, 1975, p. 36.
48. William C. Byham, *Op. Cit.*, p. 160.
49. *Ibid.*, p 160.
50. "The Use of the Assessment Centre in a Governmental Agency's Management Development Program", *Op. Cit.*, pp. 20-1.

As with any such programme, the initial cost of both the programme and its administration must be considered along with its results. The initial cost of the AMA Assessment Centre included :

The cost of the total programme including film and training of two chairmen for one week.

The cost of training the assessors within MTA.

The cost of assessing each participant. Administration costs included :

The 12 participants, 4 assessors, and one chairman's time,

The cost of facilities

The cost of meals

The cost of consumable materials

For MTA the initial cost was approximately $6585. As the materials included in this cost are re-usable, the initial outlay will be over the next 5 years. Assuming 6 programmes a year, the cost per programme will be $219.50 which is $18.29 per participant.

The administration cost for assessing each group of 12 MTA participants was approximately $2135. This comes out to $177.92 per participant. The materials consumed in the programme are $9.58 per participant, so the total cost for assessing each participant's training needs for the MTA-AMA supervisory training course is $205.79

The cost of measuring each participant's change in supervisory behaviour due to training by conducting two assessment centres, one to training and one following training, is $393.29.

This cost level was well within reason and considerably below estimates for other assessment centre programmes and other methods.

Thus we see that costs can vary and can become quite substantial when significant numbers of individuals are to undergo assesssment. Yet, if we stop and add up the expense of promotion of one individual, the cost of trainning time, new job orientation, job time lost, and the months until he can perform the new duties in a productive and efficient manner and then discover he is unfit or ineffective, the assessment price tag may no longer be expensive.

Benefits

Gino's Inc. Vice-President Curt Russell comments on a problem facing his businesses and other firms today[51] :

> The company was expanding all over the place, and in just a short time we were approaching 200 million in gross sales... Everybody was concentrating on the entrepreneurial aspects of the business, and no one was paying any attention to manpower planning. Then we realised that we had people in managerial jobs they couldn't handle. If we were going to stay successful, we needed a programme for identifying managerial potential.

It was to the assessment centre technique that Ginos turned to resolve their problem. Management development became their number one concern and the assessment technique was the means they chose in order to (1) evaluate and select the best managerial potential and (2) evaluate and determine those who were weak and set about to eliminate the weaknesses, not the individuals. Kristin Anundsen, writing in *Personnel*, comments[52] :

> If a partIcipant has been found to be weak in certain areas of managerial expertise, the company will often pay for outside courses to develop these areas.

The important consideration is that assessment can help the determination of weakness as well as strength that otherwise might go undetected.

51. Kristin Anundsen, *Op. Cit.*, p. 29.
52. *Ibid.*, p. 34

Many users have begun to realise the significant role assessment centres can play in recognition of employee training needs. Byham and Wettengel write [53]:

> In addition to anticipated management development benefits of sizeable proportions from the candidate's increased insights into personal strengths and weaknesses, the programme will also provide the basis for a management development needs survey to guide allocations of developmental efforts and services.

Besides the more obvious benefits that can accrue to an organisation indirect benefits can also be realised. Some important factors are highlighted by Byham in his article in the *Harvard Business Review*[54] :

> The first and most obvious of these dividends is candidate training. Being involved and just doing any of the exercises and functions performed at the centre, some training of the individual will take place. Second, passing through an assessment centre has a positive influence on morale and job expectations. Not only are assessees positively motivated by just taking part in the assessment activities, for the first time, perhaps, a real glimpse of what managing is really like can be experienced. Individuals can as early as this point decide that managing is not for them.

Critics can take exception to this benefit and argue the possible ramifications regarding assessee selection. Kraut and Scott in the *Journal of Applied Psychology* identify two negative aspects which they label the "Crown Prince Effect" and the "Kiss of Death Effect." The crown prince is a point already discussed in this paper, that is[55].

> attendance at an assessment programme signifies one's special status to be accompanied by sure or rapid advancement.

53. William C. Byham and Carl Wettengel, *Op. Cit.*, p. 356.
54. William C Byham, *Op. Cit.*, p. 154.
55. Allan I. Kraut and Grant J. Scott, "Validity of an Operational Management Assessment Program", *Journal of Applied Psychology*, 1972, Vol. 56, No. 2, p. 127.

Probably the most important factor and benefit a company can receive from an assessment centre programme is that there are no absolute winners, nor does anybody lose; everyone benefits from this approach.

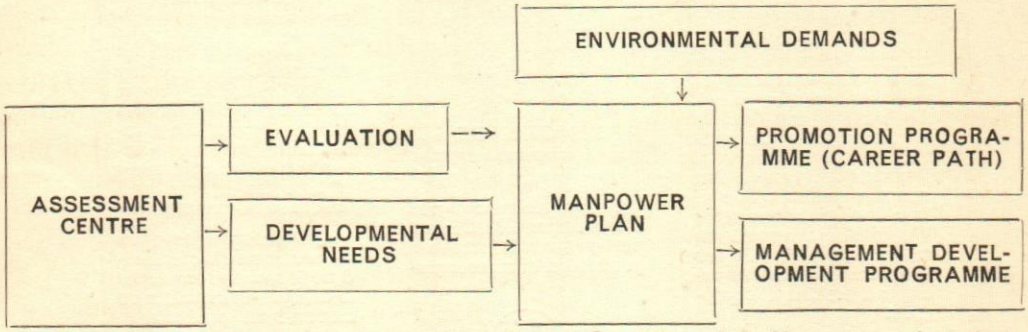
Evaluation : Conclusion

As one might presume, there are many ways to evaluate this relatively-new technique of assessment centres. The interested researcher could turn to several of the clinical and statistical studies that are available and deal with this assessment technique. Statistical analysis performed by individuals can and have indicated in concrete terms that assessment methods are superior to traditional technique.

What we have seen in this paper is not a technique that is a panacea or the ultimate selection device but rather, a methodology which when used in conjunction with the traditional means of evaluation and with significant amounts of commonsense can benefit employers and employees alike.

Chart VI illustrates the assessment centre as the future basis or foundation of what may be its direction in the future, or as Dennis Slevin sees it, as a significant part of "an effective and farsighted manpower plan.

CHART VI



Source : Dennis P Slevin, "The Assessment Centre : Breakthrough in Management Appraisal and Development", *Personnel Journal*, April, 1972, p. 261.

The assessment technique is just one further indication that business has begun to realise that human resources like other corporate assets must be guarded, protected and developed to ensure the continued vitality of the organisation, to ensure both survival and growth. □

Coking Coal Import : The Decision Problem

K. R. Shaligram*

Coking Coal (metallurgical grade, for use in the blast furnace) is an important input for the integrated steel plants. The recent debate between the steel and energy ministries, on the issue of import of coking coal, was the genesis of this paper. However, the objective of this paper is to discuss the decision problem involved.

Coking Coal

Coal is mineral in origin. It is constituted of volatiles (moisture and hydrocarbons), solid carbon, and a non-combustible solid residue called "ash". Coal for use in the blast furnace should possess the following properties :

1. The coal should be *Convertible to Coke,* by elimination of the volatiles, through the high-temperature carbonisation process. Incidentally, the elimination of volatiles implies that the percentage by weight of ash in *Coke* will be higher than the percentage in the *coal* from which it was made.

2. It should have *good caking properties.* In other words, the coke formed should be lumpy (not powdery) and hard, to withstand the compression and abrasion during its descent down the blast furnace. If the coke crumbles within the blast furnace, the fines will choke the passage of air, and cause serious problems in operations.

3. It should have *low percentage ash* by weight. The lower this percentage, the higher is the output of metal from the blast furnace. The prescribed norm is 18% under Indian conditions.

Blending of coals (a high-ash coal with a low-ash one, or a low-ash non-coking coal with a high-ash coking coal) prior to carbonisation, is one method of conserving coking coal, without sacrificing the properties

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of metallurgical coke. Efforts for blending of coal were, at least partly, frustrated by the erratic rail transportation (Johnson, p. 168).

Washing of coal, to separate the portions with low ash from those with high ash, is another method of utilising poorer grades of coal. However, the coal washeries in the country have not proved to be effective. Attempts have been made to partially substitute coke in the blast furnace with liquid fuels and pulverised coal, in an effort to conserve prime coking coal. Despite these practices, the industry still depends on bulk supplies of coking coal.

India has very limited reserves of coking coal, likely to be exhausted, within fifty years. This problem was created partly because of the use of coking coal with ash percentage as low as 9 to 10% for running the locomotives of the Indian Railways. This wastage was, of course mainly prevalent during the pre-Independence period. The ash content of coking coal had been increasing, because the low-ash upper seams in the older mines had been thus consumed. The currently-available coking coal contains upto 26% ash (*Times of India,* Jan. 14, 1978). Further, raising coal from deep mines involves many other problems. The managements of the integrated steel plants had been voicing their concern (from the early 1960's) about the rising percentage ash in the indigenous coking coal (Shaligram, p. 365). While they gained access to sources of good quality iron ore, the deteriorating quality of coking coal restricted the actual output of the blast furnaces. This was a national problem because steel is a basic industry. The country had to live with the problem, because internal economic conditions would permit no feasible solutions.

Decision Problem

In view of the comfortable foodgrain production and growing foreign exchange reserves, the Indian economy has lately been in an enviable position. With the changed economic conditions, the Government is planning to allow imports of crucial industrial inputs to utilise the foreign exchange reserves and to boost industrial output.

The steel ministry had estimated that by using an imported coking coal with less than 10% ash, the iron production (with the same blast

furnace) could be increased by 25 to 30 percent. "The ministry even tried a trial coal consignment in the steel plants. The initial results were rather good. The production did go up by 3 to 4 percent in spite of the severe power constraints during the trial period" (*Economic Times*, Dec. 1, 1977). Since the output of the same blast furnace can be increased with low-ash coking coal, the capacity utilisation is effectively higher. This increased productivity would be a contribution towards attaining the additional 1.3 million tonnes of ingot steel targeted to be achieved in 1978-79 (*Economic Times*, Jan. 4, 1978). The landed cost of the imported 4 percent ash coking coal may be of the order of Rs. 700 to 800 per tonne whereas the Indian 20 percent ash coking coal costs about Rs. 100 per tonne. These are essentially short-run considerations but the trade-offs involved are likely to remain valid in the long run also.

The decision problem, whether to import low-ash coking coal or not, can be expressed in terms of the following sequence of questions :

1. *Will the blast furnace technology survive for another fifty years?*

If the technology of iron-making changes so rapidly that the blast furnace process becomes obsolete (before the coking coal reserves run out) the best policy would be not to import coking coal. This is a problem in technological forecasting.

2. *What is the probable extent of deterioration of the Indian coking coal during the next 10 years or so?*

If the ash content is likely to increase rapidly, then perhaps, it would be better to begin importing low-ash coal to blend with the indigenous high-ash coal. Expert opinion would be required in assessing the extent of probable quality deterioration.

3. *What are the expected future prices of imported coking coal and indigenous coking coal?*

A detailed techno-economic study is called for. The price of the coking coal is linked with its ash content and location of the mines. An assessment of the improvement in blast furnace metal output for a 1 percent decline in coking coal ash content is necessary. Then the economics

can be worked out taking into consideration the incremental cost [Rs. 800—100=Rs. 700] of the low-ash imported coal, to be traded off against the realisation from the incremental output. As the prices of coking coals and steel are likely to increase over the years, these must be projected to serve as a basis for the analysis. If it is uneconomical to use only imported coal, the computations could be repeated for blends of indigenous coal with imported coal.

4. *What is the likely position of India's foreign exchange reserves over this period?*

An economic forecast would be required.

5. *Are there sufficient facilities at the ports to handle bulk imports of coking coal?*

This can be readily assessed.

These are complex questions which defy precise answers. The author is of the opinion that a decision based on approximate answers to these questions would be superior to an *ad hoc* decision.

Conclusion

Agnelli, who is regarded as an authority on steel, has predicted that the developing nations will begin to take over bulk steel production from the industrialised countries. The industrialised nations may gradually be constrained to produce more of special steels (*Economic Times*, Nov. 12, 1977). The Indian policy-makers have set fairly ambitious targets for steel production. This requires not only the establishment of new steel plants but also the operation at high efficiency of the existing plants. Increasing the productivity of the blast furnaces through the use of imported low-ash coal is a definite possibility. For instance, Japan has been importing *iron ore from India* and coking coal from other countries, and, due to operational efficiencies, has been selling finished steel in the international markets at a much lower price than quoted by India. India's comparative disadvantage is partly due to the use of indigenous high-ash coking coal. Analysis along the lines indicated in this paper would, hopefully, lead to a solution to the decision problem. □

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Empirical Issues in Total Productivity Measurement : An Experiment with Cement Industry in India

S. Acharya* & N.K. Nair**

Introduction

Attempts to measure productivity in the Indian Industry in the post-Independence period have been numerous, the approaches varying from the methods of measuring partial productivity of individual inputs to the techniques of measuring total productivity.[1] It has also been often voiced that partial productivity indices, although of some limited use are not appropriate for the overall performance evaluation of any enterprise or industry. These sources emphasise that total productivity indices have to be constructed for the purpose. However, the concept of total productivity is subject to both measurement and interpretational difficulties. In this paper, an attempt has been made to highlight these measurement and interpretation problems and to suggest means to deal with them. The issues discussed are limited to those related to measurement and interpretation of total productivity at an aggregate (industry) level through a time series. The exercise is then extended to the empirical measurement of total productivity of Cement Industry in India.

Concept of Total Productivity

Total productivity is defined as the contribution of all the inputs, they being combined in some composite fashion. A time series of such an index could reflect the inter-temporal changes in the capacity of the production system to generate output. Traditionally these inter-temporal changes are attributed to the technical progress or to managerial

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1. For a critical brief survey of these studies see, National Productivity Council, (1977).

(organisational) innovations. Since the reference is to the capacity of the 'production system', only factor inputs are considered as constituting this system. Material inputs are excluded by implication. Total productivity indices implicitly involve the underlying production function of the activity which is under study. The simplest form of total productivity ratio, the 'Kendrick' index, is arrived at by an arithmetic combination of the weighted inputs, the weights being the factor prices at the base year.[2] This involves a linear production function. But since a linear production function holds good only under rare conditions, the residual factor method of total productivity, based on a neo-classical production function[3] is considered more realistic and hence, one variant or the other of such a function has acquired tremendous popularity in current literature. The method is briefly discussed here.

Let a homogenous production function of degree 1 be written as

$$Q = A(t) K^a L^b \qquad \ldots(1)$$

where

Q = Output, K = Capital, L = Labour

a & b = partial elasticity coefficients

and A(t), the total (residual) productivity component assumed to be containing an autonomously-generated residual (or disembodied) technical progress. The growth of total productivity can be derived from the above production function as ;

$$1/A(t).\ dA(t)/dt = 1/Q.\ dQ/dt - a/k.\ dk/dt - b/L.\ dL/dt \qquad \ldots(2)$$

---

2. The formula can be written as

$$\text{Total productivity} = \frac{P_o\ Q_t}{Wo\ L_t + r_o\ Kt}$$

Q, L and K refer to the output, labour and capital; P, W and r are the prices of outputs, labour L and capital K respectively. o & t refer to the base and current years. See for details Kendrick (1961).

3. See for details, Solow (1957).

The corresponding index of total productivity can be arrived at by using the formula :

$$A(t+1)=A(t)\ [1+(1/A(t).\ dA(t)/dt] \qquad \ldots(3)$$

The above index can be computed once the concerned production function is estimated.[4]

Some Measurement Problems

The above-said index, however, is subject to major measurement and interpretation problems, some of which are discussed in some detail below :

To begin with, consider the practice of quantifying the variables in financial terms at current market values. In such a case first, for very clear reasons, the relative price effect is likely to distort the marginal contributions of the factor inputs and secondly, there is likely to be a fallacy in the interpretation of coefficients. To elaborate the second point, consider the case of using the wage bill to represent the labour contribution. Wages are factor rewards and are not factor contributions of employment, and hence the partial elasticity would represent only the output elasticity of wages, which is not the same as the proportional contribution of labour from additional employment. Next, consider the use of factor inputs measured in physical units to overcome the problems mentioned above. In the case of labour, it is possible to take the total man-hours worked as a measure of labour input at the first instance but for capital, there exists no corresponding measure in physical terms. Similarly, when more than one product is manufactured in the same process, the output too is measured in financial terms at constant prices. However, though the use of figures at constant prices eliminates the quantitative biases in the coefficients of a production function, the reallocation effects of price movements stay, mainly because of the *ex-post* nature of the data.

4. The two approaches to total productivity measurement described above include only the disembodied technical progress. The methods of estimating embodied and induced technical progress are far from perfect. Some attempts have been made in Arrow (1962), Backmann and Sato (1968), Solow (1959).

Thirdly, there might be a discrepancy between the stock and flow concepts of the variables. While the output is a flow variable, capital refers to a stock. To overcome this problem, sometimes the machine-hours-worked are taken to represent capital.[5] This measure is also subject to serious limitations since 'homogeneity' of hours-worked by different machines is unattained. The argument is true in the case of labour measurement also. Since, the number of men employed is a stock factor, its corresponding flow factor, the total man-hours-worked is taken to represent labour input. But here again the addition of hours worked by workers of different skills yields erroneous results.

As far as the capital input valuation is concerned, the money-value of the stock of capital deflated by the use of perpetual inventory method, though not ideal, seems to be satisfactory. To arrive at a corresponding flow variable, this deflated capital stock can be adjusted with the capital-utilisation ratio.

As regards labour input measurement, only if variation in wages is preceded by a proportional variation in the quantum of workdone, can wages[6] be taken to represent labour. Since, this is not true almost anywhere,[7] wages cannot truly represent the actual labour input. Unfortunately, there seems to be no way out of this crude approximation.

Specification and Interpretation Problems

The foremost difficulty in the interpretation of a specified production function arises when changes in total productivity are identified with technical progress. The type of production function specified in equation (1) above represents only the disembodied technical progress and alternative specification is not attempted for reasons already mentioned (foot-note 4). Now since in real life, disembodied, embodied

5. See National Productivity Council (1976).
6. Since wages are supposed to be paid according to the skill levels of workers, it could be taken to represent a weighted index of workers' input, subject to other conditions being fulfilled.
7. Studies in wage determination often show a large number of wage variants. See for example, Papola (1972).

and induced technical progress all occur with time and often overlap each other, the time variable introduced to capture the disembodied technical progress would often also capture the contributions of embodied and induced technical progress. This causes two kinds of distortions in the results. First, the total productivity index is likely to have an upward bias. This is because of the fact that the coefficient of technical progress would include undefined effects of embodied and induced technical progress.

Secondly, since embodied technical progress renders the factors of production heterogenous through the time series as far as the flow of services is concerned, any attempt to 'homogenise' them through the introduction of a time variable would be a deliberate attempt to separate out all the contribution of technical progress—disembodied, embodied or induced. Thus the embodied technical progress, which augments the quality of factors of production in the subsequent periods is erroneously lumped with the disembodied technical progress and is not permitted to show the improved factor quality. As a result, the factor coefficients would be artificially depressed.

Jorgenson & Grilliches[8] consider the existence of total productivity purely due to erroneous measurement of inputs and outputs. They suggest that "within the framework of social accounting the hypothesis is that if real product and real factor inputs are accurately accounted for, the observed growth of total productivity is negligible." In other words, any technical progress/organisational efficiency is due to an augmentation in factor efficiency and a proportionate increase in factor rewards should follow. The errors, they point out, due to which a residual emerges are the same as those discussed above, i.e., due to aggregation of data, erroneous measurement of variables and inappropriate investment goods prices. Mo-huan Hsing[9] also maintains that the residual in a production function exists due to shifts in the demand and supply functions of factors of production and cannot be termed as due to total productivity augmentation.

In view of the above contentions, it is questionable whether a production function exercise to measure total productivity should be taken seriously.

8. Jorgenson & Grilliches (1964).
9. Mo-Haun Hsing (1976).

In what follows, it is argued that in a limited preview, some useful conclusions can still be drawn from such exercises.

It should be noted that if all the variables are measured in flow terms and in physical units, most of the discrepencies due to shifts in factor demand and supply and due to erroneous measurement of variables can be eliminated. This is because the variation in factor compensation due to shifts in demand or supply do not enter into the production function. However, this requires the use of short-time series.[10] The only discrepency which would still remain is the aggregation bias, say for instance, due to a horizontal summing of hours worked by men of different skills. This discrepency is unlikely to be corrected under conditions of imperfect markets.

Keeping the above in view, if an estimated production function gives rise to a significanct residual coefficient, it is solely due to total productivity agumentation, though with some aggregation errors. However, this contention would hold only if the time series is short enough, such that large non-neutral shifts in the production functions do not occur. How 'short' should be the time series, is the researchers' judgments based on how fast the production structure shifts with new innovations.

Production Function Estimation

In this section, a total productivity index is estimated using data for cement industry from the Annual Survey of Industries for the period 1959-71. Additional data on prices and capacity utilisation are obtained from the Reserve Bank of India Bulletins and the Cement Controller's Office.

This time-series is considered short for a capital intensive industry like cement, where relative homogeneity can be assumed to exist over at least a decade, considering the large cost of mass replacement of machinery and equipment.

To begin with, the form of the production function is specified on the

10. This runs contrary to the statistical requirements.

basis of the estimated elasticity of substitution from the following equation :[11]

$$\text{Log}\left(\frac{VA}{L}\right)=a_o+a_1 \log\left(\frac{WS}{L}\right)+a_2 t \qquad \ldots(4)$$

where

VA = Value added

L = Labour input

WS = Wages & Salaries

t = time

a_1 would give an estimate of the elasticity of substitution for the family of production functions included in the CES production function category. Details of the choice of variables used for estimating equation (4) and the corresponding production function are explained below :

Since cement is more or less a single product industry, the quantity of cement (output) is measured in lakh of tonnes. Labour input is measured in lakh of man-hours-worked. The capital input is arrived by deflating the annual additions to the book-value of fixed assets by the index of whole-sale prices of machinery on the basis of the perpetual inventory method. This is then further adjusted to capacity utilisation of the industry in each period to arrive at the capital flow variable. Capital is measured in lakh of rupees. The value added and wages and salaries are measured in lakh of rupees at current prices since equation (4) is unaffected by differential price movements of inputs.

The estimates of the elasticity of substitution are given in Table 1. The Equation No. 1 of the table is considerably distorted due to multicollinearity, the simple correlation between (WS/L) and t being of the order of 0.99. Equation No. 2 in Table 1 can be chosen to determine the elasticity of substitution.

Equation No. 2 in Table 1 shows an elasticity coefficient of 0.86 which when tested is not significantly different from unity at 5 percent confidence level in a t-test. This implies that not much would be lost

11. See for explanation, Arrow, Chenery, Minhas and Solow (1961)

Table 1 : Estimate of the Elasticity of Substitution

Eqn. No.	Constant Term	Log(WS/L)	t	R^2	F	dw
1.	0.80	0.16 (0.12)	0.06 (0.55)	0.80	24.98	1.50
2.	0.97	0.86 (7.28)	—	0.81	52.99	1.56

Notes : (1) figures in the brackets are the respective t-values.
(2) the dependent variable in both the equations is log (VA/L).

in approximating the input-output relationship on the basis of a Cobb-Douglas production function. The results of the least squares estimation of the Cobb-Douglas function are tabulated in Table 2. The model is tried under alternative specifications to overcome problems of multi-collinearity.

Table 2 : Estimate of the Production Function

Eqn. No.	Constant Term	Log K	Log L	t	R^2	F	d.w.
1.	3.50	— 0.85 (10.38)	0.18 (0.95)	0.06 (5.00)	0.99	271.24	2.24
2.	4.16	0.59 (5.64)	0.56 (1.75)		0.95	106.48	2.23

Note : (1) K and L represent capital and labour inputs as defined earlier.
(2) Figures in brackets are the respective t-values.
(3) In both the above equations, the dependent variable is the output Q.

The Equation No. 1 in Table 2 is considerably distorted by multi-collinearity as the time trend variable is highly correlated with the other

independent variables. Equation No. 2 can thus be taken to represent the production function of the industry.

On the basis of the estimates obtained from the Equation No. 2 in Table 2, Eqation 2 mentioned in the section 2 is computed, using discrete time-interval data on Q, K and L. Accordingly, A(t), the total productivity index is calculated using equation (3) of section 2 and fixing the base year of A(t) as 100. Estimates of [1/A(t). d(t)/dt] and A(t) are presented in Table 3.

Table 3 : Total Productivity Estimates

Year	1/A(t). dA(t)/dt	A(t) (base 1959)
1960	0.011	101.1
1961	0.029	104.0
1962	0.043	108.5
1963	0.001	108.5
1964	—0.024	106.0
1965	0.030	109.0
1966	0.036	113.1
9167	—0.117	99.9
1968	—0.024	97.5
1969	0.057	103.1
1970	—0.064	95.5
1971	0.130	109.0

The inferences derlved from the production function estimates and the corresponding total productivity index can be summarised briefly as follows :

(1) The coefficient of capital is large and statistically more significant when compared to the labour coefficient, complying with the requireiments of a capital-intensive industry like cement. The labour coefficient ts significant only at 10 percent level of confidence (according to a t-test), implying that minor variations in labour input may not affect the output significantly, a typical characteristic of a capital-intensive process industry.

(2) There may be increasing returns-to-scale, implying that, technically, the industry can reap higher returns by expansion. However, since decisions of expansion are not solely dependent on the technical relationship between input and output, the result need not necessarily imply that the industry should expand. The evidence of increasing returns to scale needs to be verified by simultaneosly considering the supply functions of the factor inputs.

(3) The total productivity index shows no monotonic trend. There is a rise of about 13 percent, registered through 1959-66 followed by a steep decline in the following years even below the base year. Total productivity fluctuates alternatively thereafter, exhibiting a steep rise in the final year 1971. No stable growth is registered through the sixties. It can also be observed that the fall in productivity has occurred during the years 1966-68, the period of depression in India. □

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Design of Preventive Maintenance Schedule

A. D. Gupta* & S. P. Tanwar**

Introduction

With the rapid development of mechanisation and automation, the problem of machine maintenance has become very important for improving availability of equipment for productive use. The objective can partly be satisfied by designing the equipment for maintenance. Through perfect design and selection of suitable materials for various components of a system, the reliability can be improved so that the system functions satisfactorily most of the time. However, in spite of our best efforts, breakdowns cannot be eliminated and they occur as a matter of chance. An equipment should be designed such that its parts are easily accessible so that in case of a breakdown, it can be repaired back to working condition in a short span of time. Also, it is equally important to upgrade the equipment reliability when it is in service so that a breakdown is 'postponed' and the equipment remains productive for a longer period of time. This aim can be accomplished by performing preventive maintenance in anticipation of failure. The success of a preventive maintenance programme depends upon its appropriate scheduling.

If a machine breaks down when in use, it may have to remain idle for considerable length of time due to extensive repairs required. If the machine forms integral part of a unit, its failure may cause the entire unit to trip down. Sometimes a breakdown is a safety hazard and it may lead to catastrophic failure of the system. Therefore, a breakdown is usually very costly and the probability of its occurrence should be reduced through efficient Preventive Maintenance Planning. However, we should be cautious in deciding the level and frequency of Preventive Maintenance to be performed. If carried out too frequently, preventive maintenance itself may result in high idle time of the production facility.

This paper deals with the determination of preventive maintenance interval or period, taking into account the stochastic behaviour or failures

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A. Model for Known Distribution of Time to Failure

James A. Parson [3] and J.J. McCall [4] have developed a mathematical model for the case of known breakdown time distribution.

Let

t = Equipment failure time or free run time (non-negative random variable)

$f(t)$ = Probability density function of t

$F(t)$ = Cumulative probability density function of t

C_f = Average cost of a breakdown

C_p = Average cost of a preventive maintenance

t_o = Preventive maintenance period

$$F(t) = \int_0^t f(t)\,dt$$

$$S(t) = \int_t^{\infty} f(t)\,dt$$

$F(t)$ denotes the probability that the equipment fails by time t.

$S(t)$ denotes the probability that the equipment survives up to time t.

$$F(t) + S(t) = 1$$

Now average cost per unit time ($\bar{C}$) is given by

$$\bar{C} = \frac{C - (C_f - C_p)S(t_o)}{\int_0^{t_o} S(t)\,dt}$$

The cost $\bar{C}$ is calculated with different values of t_o and that value of

t_o ($^*t_o$) is chosen as optimum which gives minimum average cost per unit time. Preventive maintenance is performed after $^*t_o$ time of continuous operation without failure. If the system fails before time $^*t_o$, breakdown repair is carried out and preventive maintenance is rescheduled at time $^*t_o$ after failure repair.

B. Model for Unknown Distribution of Time to Failure

Sometimes, due to lack of information or data, the parameters (mean and variance) of failure time distribution cannot be determined, but there exists an estimate for the mean life (μ) of the equipment. In such situation, Chebyschev type Bounding Technique can be used to find preventive maintenance period [4]. The probability that equipment has not failed by age t is bounded from below by V(t).

$$S(t)=1-F(t)\geqslant V(t)=\begin{cases} e^{-\frac{t}{\mu}} & \text{if } t\leqslant\mu \\ o & \text{otherwise.}\end{cases}$$

Similarly, the probability of survival by age t is also bounded from above by w(t).

$$S(t)=1-F(t)\leqslant W(t)=1-x_o \text{ for } t>\mu$$

$$\text{where } x_o \text{ satisfies } 1-x_o = e^{-\frac{x_o t}{\mu}}$$

These bounds can be used to assess the relative merit of various preventive maintenance intervals.

The average cost per unit time with preventive maintenance period t_o is bounded by the following expression :

$$\frac{C_p W(t_o)+C_f[1-W(t_o)]}{\int_o^{t_o} W(t)dt} \leqslant \bar{C} \leqslant \frac{C_p V(t_o)+C_f[1-Vt_o)]}{\int_o^{t_o} V(t)dt}$$

The upper limit of cost $\bar{C}$ is calculated for different values of t_o and that value of t_o ($^*t_o$) selected as optimum which gives minimum upper bound.

The above models are applicable for equipments which exhibit increasing failure rate with time.

Determination of Time to Failure Distribution

For determining preventive maintenance schedule, it is required to estimate the inter-arrival breakdown time distribution. Two years' breakdown data (when there were no preventive maintenance policies) was collected from equipment history cards for Boiler Feed Pump. A histogram was drawn and parameters of the distribution estimated. The failure time distribution was found normal by applying Chisquare test of goodness of fit (Table 1).

Mean time to failure (μ) = 50 days

Standard deviation (σ) = 20 days

Therefore, probability density function

$$f(t) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{\frac{(t-\mu)^2}{2\sigma^2}}$$

$$f(t) = \frac{1}{20\sqrt{2\pi}} e^{\frac{(t-50)^2}{800}}$$

By integrating probability density function f(t), other functions such as cumulative density function F(t) and reliability function S(t) can be evaluated (Model A).

For main Turbine, sufficient data was not available to find its failure distribution. However, the expected life (μ) was estimated as 60 days (Model B).

Table 1

Name of Equipment : Boiler Feed Pump

Time Interval (Days)	*Observed Frequency* (f_o)	*Expected Frequency* (f_e)	$\frac{(f_o-f_e)^2}{f_e}$
0—10	6	4	1.00
10—20	10	8	.50
20—30	13	16	.56
30—40	28	24	.75
40—50	34	30	.53
50—60	24	28	.57
60—70	22	21	·04
70—80	9	12	·75
80—90	5	6	.17
90—100	5	2	4.50

Sum x^2 = 9.37

Number of degrees of freedom = 10—1—2 = 7

For 5% error level, from Chi-square distribution tables, C = 14.07

Since $x^2 < C$, accept normality hypothesis

∴ Failures of Boiler Feed Pump follow a normal distribution

Cost Estimates

To determine optimum preventive maintenance schedule, it is necessary to estimate the average costs of a breakdown (C) and a preventive maintenance (C_p). Each maintenance (whether performed before or after failure) is associated with the costs of labour, spare parts and loss of production. Knowing the average manhours required (from past data) and payment rate, labour cost can be estimated. If we know the cost of spare parts consumed and number of maintenances performed in a year, we can estimate average cost of spares for each type of maintenance. Cost of production loss can be estimated as the revenue loss due to equipment downtime. For this pursose, average downtime (both for preventive maintenance and breakdown repair) and rate of revenue loss must be determined. Adding the three cost components, values of C_f and C_p were estimated as follows :

	C_f	C_p
Boiler Feed Pump	Rs. 7,980	Rs. 830
Main Turbine	Rs. 3,05,000	Rs. 58,900

Preventive Maintenance Schedule

Knowing failure density function, mean equipment life, average costs of a preventive maintenance and a failure, values of $\overline{C}$ (average total cost/day) were calculated with the help of computer. Various maintenance periods (varying in steps of 5 days) were tested (Table 2). Optimum preventive maintenance period, for which total daily cost is minimum, is 25 days for Boiler Feed Pump and 40 days for the Turbine. Optimum preventive maintenance period of 40 days (as compared to 60 days as per existing practice in the plant) for the main Turbine is expected to result in potential savings of the order of Rs. 4,000 per day. It would also improve equipment availability or utilisation from 82% to 90% due to reduction in equipment downtime.

Table 2

Equipment : Boiler Feed Pump

Preventive Maintenance Period (*Days*)	*Total Average Cost* (*Rs./Day*)
5	319
10	172
15	75
20	58
25 (optimum)	53
30	55
35	61
40	68
45	77
50	86
Equiptment : Main Turbine	
5	67,300
10	36,600
15	26,400
20	21,300
25	18,200
30	16,200
35	14,800
40 (optimum)	13,700
45	13,900
50	14,300
55	15,800
60	17,800

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Cost of Cultivation of Jute : A Case Study

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In this paper, an attempt is made to present a case study on the cost of cultivation of jute and mesta, pinpointing the inadequacy in the methods officially adopted therefor and the manner in which such costs should be collected, collated and presented for different purposes. The paper seeks to underscore that there exists a direct relationship between the productivity levels attained and the cost of cultivation incurred and/or imputed.

In calculating the cost of cultivation of individual crops, it would not be out of place to mention that the computational procedure would differ when single crops are raised during a crop season *vis-a-vis* multiple crops. The present methods of pricing of agricultural products do not distinguish between large and small farmers. Our pricing methods also do not distinguish between single crops and multiple cropping, not only during different crop seasons but also in the same crop season. A small instance will suffice here. In Bangladesh, there are several districts where farm lands remain inundated for a good part of the year. The months of *Chaitra* and *Baishakh* would witness sowing different varieties of seeds in the same piece of land covering such items as jute, aush and aman paddy. Aush paddy and jute would be harvested during the rainy season and the field would be occupied only by aman paddy which would be harvested towards the end of *Kartick* or *Agrahayana*. The decomposed roots of paddy and jute along with the deposit of rich alluvium would provide a natural manure system every year to compenstate any possible loss of fertility during the earlier year. To calculate cost of individual crops in such a case would raise complicated issues concerning allocation and apportionment of different types of costs relevant for raising these crops. In India, the variations in practice with respect to crops, crop seasons and crop-mixes have been wide, so that no one method would be completely satisfactory. Accommodating these possible variations, it is, however, necessary to devise systems of cost compilation and cost computation on the basis of which the farmers may remain informed and Government

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may adopt suitable and sensitive policies satisfying the ends of both producers and consumers. The case dealt within this paper raises some such issues.

The area under cultivation of jute and mesta in different States as also the total acreage and production of jute and mesta for the country as a whole have been presented in Tables 1 and 2. The trends in both area and production have been rather uncertain and increased production has come generally from extension of area under cultivation than from increased productivity. The statewise variations in productivity levels are also apparent from Table 5. Figures for this Table have been calculated on the basis of those in Tables 1 and 2.

Thus, as shown in Table 1, area under jute and mesta was 552 thousand hectares in 1967-68 of which that under jute was 496 thousand hectares and mesta 56 thousand hectares. In 1968-69, there was a sharp fall in the area under cultivation of jute coming to as low as 269 thousand hectares while that under mesta was only 42 thousand hectares, the total being 311 thousand hectares. The erratic behaviour in the area under cultivation ot jute in West Bengal will be seen from the fact that from 438 thousand hectares in 1969-70, the figure came down to 335 thousand hectares in 1975-76, raising to 441 thousand hectares in 1976-77. The area under mesta, on the other hand, declined from 62 thousand hectares in 1969-70 to 29 thousand hectares in 1976-77. In relation to 1975-76 figures, however, the position in 1976-77 is somewhat better. Thus, while in 1975-76 the total area under cultivation of jute was 335 thousand hectares, under mesta 32 thousand hectares and the total 367 thousand hectares, in 1976-77 the area under jute cultivation was 441 thousand hectares, under mesta 29 thousand hectares and the total 470 thousand hectares. The area under cultivation of jute and mesta in the other States like Assam, Bihar, Orissa, Tripura, Andhra Pradesh and Uttar Pradesh together comprises less than 50 percent of the total area under cultivation of these two crops. In terms of production, as shown in Table 2, more than 50 percent comes from West Bengal. Tables 1 and 2 together formed the basis of Table 5 wherein details of productivity of jute and mesta during the period from 1967-68 to 1976-77 have been given. The levels of productivity have not been uniform, either in the individual States in which jute and mesta are grown or in the same State over time.

On an all-India average basis, production of jute in bales per hectare has varied from 7.182 in 1967-68 to 7.235 in 1976-77. In between, however, the all-India average declined to 5.562 in 1968-69, 6.593 in 1970-71, 6.733 in 1974-75 and 6.974 in 1971-72. Mesta production in bales per hectare varied from 3.963 bales per hectare in 1967-68 to 3.236 bales per hectare in 1968-69, to rise to 3.509 in 1969-70 and 4.270 in 1974-75. Production of mesta in bales per hectare was 4.357 in 1975-76. Total of jute and mesta production on an all-India basis in bales per hectare showed a declining trend in 1968-69 when the figures stood at 4.755 as against 6.321 during the earlier year. During the period, the total figures stood below 6 bales per hectare in 1970-71 when production stood at 5.740. From then on, the trend has been upward rising to 6.446 in 1975-76, *albeit* being broken in between with slight decreases in 1972-73 and 1974-75 as against their respective earlier years.

Tables 3 and 4 present the estimates of cost of production of jute in terms of per acre cost and per quintal cost. Among the cost components, exhaustive details have been provided in the Table, thanks to the searching analysis made by the Committee on Public Undertakings in their Third and Eighth Report concerning Jute Corporation of India Limited, Jute and Exploitation of Jute Growers and on Jute Corporation of India Limited (Government's Unfair Pricing Policy for Raw Jute) respectively. These Reports were presented to Lok Sabha and laid in Rajya Sabha in April, 1978. These details are not only relevant for deciding on official policy but also essential from the point of view of the farmer in knowing and judging the direction of his effort and the likely returns on various crops. The per acre cost figures are, however, likely to vary from period to period, may be season to season and from crop to crop or even different varieties of each crop commanding different prices. The costs presented in the Table assume a productivity level of 6.30 quintals per acre. Though this level is well within bounds or possibility, variations in productivity levels as actually happened during the period from 1967-68 to 1976-77 would materially affect the per quintal costs of the individual items like jute and mesta. Tables 6 and 7 indicate such variations in respect of fixed and variable costs. However, in regard to the methodology of computation of these costs, the Committee took a serious view of the underestimation of these costs and pinpointed the deficiencies in this respect. Both the Agricultural Prices Commission and the Directorate of Economics

and Statistics have been rapped by the Committee for these inadequacies in the cost data presented and used by them for determining official policy concerning prices, etc. In this connection, the Committee also noted the divergence in the data presented by the aforementioned bodies and those collected by the State Department of Agriculture. Pinpointing the deficiency in calculations of Directorate of Economics and Statistics and the figures of cost as taken into account by the West Bengal Government, the Committee have presented relevant figures in Table 8.

One of the major purposes behind this study is that at present a good deal of time gap remains between the incidence of cost on the farm front and reporting thereupon to the official agencies at different levels like the State Government through different channels and the Central Ministry of Agriculture and Irrigation. The Committee on Public Undertakings in their Eighth Report underlined that under the comprehensive scheme for cost of cultivation of principal crops, data are collected *post facto* on the basis of an entire year.

Fixed cost elements and joint cost elements require apportionment which take an inordinately long time. This gap can be effectively bridged only when the farmers themselves start maintaining their records and present relevant information in some acceptable formats. Moreover, collection of figures of cost of cultivation under the comprehensive scheme by designated officers of agricultural universities in different States is a rather unsatisfactory arrangement in the sense that cost and management accounting has already attained a fairly-high degree of sophistication and some degree of knowledgeability should be shown right at the level of collection of data which provide the basis on which further edifices are built up at higher levels. In no case, the quality of the basic data can be improved at subsequent stages and its veracity of the field level data that should attract serious attention of all concerned. Moreover, one of the more-widely accepted tenets of cost and management accounting is its use as a mechanism of control. This control is most effective, as far as agriculture is concerned, at the level of the farmer himself and he should be oriented towards exercise of these controls, may be in a rudimentary form, may be unsophisticated, may be not complete in every respect, but must be truthful. It should not be expected that apportionment or allocation of individual items of expenditure to crops be made by the farmer himself

distinguishing between fixed and variable expenses and other requirements. Once all the details are available in a format chosen officially for the purpose, further sophistication should not be very difficult. The important point here is that the farmer should be given adequate know-how to control his costs and to explore ways of optimising his output *vis-a-vis* the inputs, physical and financial. It is in this respect that the cost and management accounting profession in this country has a significant role to play, perhaps in collaboration with the agricultural universities of different States in regard not only to calculation of actual cost of different crops during a season or a year but also to introduction of budgetary control and standard costing techniques at the farm level to let the farmer know and judge how he is doing *vis-a-vis* what he should have done.

Even now farm level records are not entirely absent. Schedules are prepared by different Argo Economic Research Centres under various universities of the country and also agricultural universities in different States as to the income and expenditure pattern of households from different occupations that broadly come under farming. In this respect also both the data and the method of their collection can be further sharpened and made increasingly more purposive if cost and management accountants are associated in different capacities. So far agricultural costing has been organised almost parallel to, and independent of, the cost and management accounting profession. This gap should be bridged before long, so that the cost and management accounting profession widens its horizon while the biggest industry in this country, namely agriculture, receives the benefit of top grade professional service.

Table 1 : Area Under Jute and Mesta

('000 hectares)

States	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	
West Bengal											
Jute	496	269	438	407	461	367	419	370	335	441	
Mesta	56	42	62	66	62	48	69	48	32	29	(28)
Total	552	311	500	475	523	415	488	418	367	470	
Assam											
Jute	146	108	122	129	143	134	149	121	94	105	
Mesta	9	7	7	6	10	8	13	12	10	11	(10)
Total	155	115	129	135	153	142	162	133	104	116	
Bihar											
Jute	158	90	138	142	131	131	144	105	100	126	
Mesta	38	25	33	36	32	31	38	28	20	31	(29)
Total	196	113	171	170	163	162	182	133	129	157	
Orissa											
Jute	52	42	45	44	52	42	57	47	38	47	
Mesta	26	25	28	29	31	26	36	37	37	38	(37)
Total	78	67	73	73	83	68	93	84	75	85	
Tripura											
Jute	12	7	7	8	9	8	8	6	6	6	
Mesta	13	7	8	9	10	10	11	9	10	10	(10)
Total	25	14	15	17	19	18	19	15	16	16	
Andhra Pradesh											
Mesta	85	87	86	87	91	101	107	88	95	106	(86)
Uttar Pradesh											
Jute	16	11	11	13	12	10	9	9	9	9	
Total											
Jute	880	527	768	749	815	700	793	664	587	739	
Mesta	321	280	322	330	296	293	370	319	314	324	(298)
Total	1201	807	1090	1079	1111	993	1163	983	901	1063	

Notes : (1) Figures for Assam include Meghalaya up to 1968-69.

(2) For 1976-77, figures for jute are final estimates and those for mesta are second estimates.

(3) Figures in brackets in column 11 are the corresponding estimates of area for 1975-76.

Source : Committee on Public Undertakings (1977-78), (Sixth Lok Sabha), Eighth Report on Jute Corporation of India Limited, (Government's Unfair Pricing Policy for Raw Jute), (Ministry of Industry), Lok Sabha Secretariat, New Delhi, April 1978, pp. 3-4

Table 2 : Production of Jute and Mesta

('000 bales of 180 Kgs. each)

State	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
West Bengal										
Jute	3854	1330	3399	2684	3469	2712	3673	2608	2686	3473
Mesta	349	214	337	384	354	234	365	271	172	
Total	4203	1544	3736	3068	3823	2946	4038	2879	2858	
Assam										
Jute	1049	779	1082	937	1138	1010	1136	825	723	704
Mesta	32	27	28	24	36	32	48	43	39	
Total	1081	806	1110	961	1174	1042	1184	868	762	
Bihar										
Jute	833	400	668	773	470	687	842	546	612	602
Mesta	195	80	125	171	99	149	201	116	136	
Total	1020	480	793	944	569	836	1043	662	748	
Orissa										
Jute	362	290	315	328	380	382	491	333	291	405
Mesta	98	120	140	152	174	131	175	176	201	
Total	460	410	455	480	554	513	576	309	492	
Tripura										
Jute	92	45	57	65	68	58	49	50	45	37
Mesta	71	44	49	55	55	57	60	55	60	
Total	163	89	106	120	123	115	109	105	105	
Andhra Pradesh										
Mesta	386	271	278	296	309	418	438	524	569	
Uttar Pradesh										
Jute	132	88	86	103	102	88	79	75	46	81
All India										
Jute	6320	2931	5655	4938	5684	4978	6220	4471	4440	5347
Mesta	1272	906	1130	1255	1150	1112	1416	1362	1368	
TOTAL	7592	3837	6785	6193	6834	6090	7676	5833	5808	

Committee on Public Undertakings (1977-78), (Sixth Lok Sabha), Third Report on Jute Corporation of India Ltd, Jute and Exploitation of Jute Growers, (Ministry of Industry), Lok Sabha Secretariat, New Delhi, April 1978, p. 2

Table 3 : Estimate of Cost of Production of Jute

Items	Cost per acre
Human Labour	Rs.
Faimly	287.37
Hired	542.46
Bullock Labour	126.66
Seeds	19.04
Fertilizers and manures	63.79
Plant protection chemicals	12.87
Depreciation of implements	51.98
Irrigation	11.53
Land revenue and irrigation tax	5.69
Interest on capital	623.84
Management	480.00
MISCELLANEOUS	
(a) Chemicals other than fertilizers and plant protection chemicals	2.00
(b) Bamboo for drying fibre	4.84
(c) Weight (e. g. logs, banana trunks, etc.) for steeping jute plant	2.00
(d) Hiring of sprayers, seed-drills, wheel hoes, etc.	4.00
(e) Rent for hiring of retting tanks	8.41
(f) Others	0.50
MARKETING CHARGES	
(a) Cost of transport (up and down)	6.58
(b) Weight loss	12.38
(c) Rejection	3.92
(d) Storage and godown charges	5 60
(e) Brokerage	17.45
(f) Dhalta and iswarbritti	11.36
(g) Tola	7.00
(h) Others	5.00
TOTAL	2377.27
Yield per acre (Quintals)	6.30
Cost per quintal including by-product	Rs. 377.34
Cost per quintal excluding by-product	Rs. 344.34

Notes :

1. Both family and hired labour have been evaluated on the basis of statutory minimum wages of Rs. 8.10 per day of 8 working hours.

2. Interest on capital has been considered to be 12% per annum calculated for six months. Capital includes land as well as bullocks and other fixed assets of farmers and working capital, i. e., all paid-out expenses. Land values have been calculated on the basis of weighted averages of values of irrigated and unirrigated land in the various districts of the State.

3. Management costs have been assesssed @ Rs. 800.00 per month per 10 acres for a period of 6 months. This provision has been made for cost of management and supervision (including risk taking) which should be conceptually different from the cost of family labour. From the viewpoint of agricultural price policy, some 'normal' return to the managerial factor should evidently be included in the cost of production. Other evpenses have been calculated on the basis of actual field data and through contact with agricultural officials.

4. The cost estimates for the State as a whole have been derived on the basis of a weighted average of the cost estimates for the 3 zones, the weights being the relative production in the three zones. To be precise, these weights are 27, 65 and 8 for Zone I, Zone II and Zone III respectively out of a total of 100.

Table 4 : Estimates of Cost of Production of Mesta

Items	Cost per acre (Rs.)	Physical units
Human labour	615.60	76 mandays
Bullock labour	120.00	24 bullock days
Seeds	30.00	6.0 kg./acre
Fertilizers and manures	36.00	FYM-3 carts load/acre
Plant protection chemicals	6.40	
Depreciation of implements	13.50	
Irrigation	—	
Rent	4.00	
Interest on capital	229.40	Fixed and working capital @ 12% per annum
Management	480.00	@ Rs. 80.00 per acre per month for six months
Market charges	53.10	Transport, weight loss, rejection, brokerage, storage, dhalta, etc.
Miscellaneous	8.00	Cost of bamboo/logs for steeping, hiring of retting tank, etc.
TOTAL	1596.00	
Yield of mesta fibre per acre (quintal)	4.90	
Value of by-product (Rs.)	205.80	
Cost per quintal of fibre (Rs.) (excluding by-product)	283.71	
Cost per quintal of fibre (Rs.) (including by-product)	325.71	

Committee on Public Undertakings (1977-78), (Sixth Lok Sabha), Eighth Report on Jute Corporation of India Ltd. (Government's Unfair Pricing Policy for Raw Jute), (Ministry of Industry), Lok Sabha Secretariat, New Delhi, April 1978, pp. 15-16.

Table 5 : Productivity of Jute and Mesta

(Bales per hectare)

State	1967-68	1968-69	1669-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
West Bengal										
Jute	7.770	4.944	7.760	6.595	7.525	7.390	8.766	7.049	8.018	7.875
Mesta	6.232	5.095	5.435	5.818	5.710	4.875	5.299	5.646	5.375	
Total	7.614	4.965	7.472	6.459	7.310	7.099	8.275	6.888	7.787	
Assam										
Jute	7.185	7.213	8.869	7.264	7.958	7.537	7.624	6.818	7.691	6.705
Mesta	3.556	3.857	4.000	4.000	3.600	4.000	3.392	3.583	3.900	
Total	6.974	7.009	8.605	7.119	7.673	7.338	7.309	6.526	7.327	
Bihar										
Jute	5.272	4.444	4.841	5.444	3.588	5.244	5.847	5.200	6.120	4.778
Mesta	5.132	3.200	3.788	4.750	3.094	4.806	5.289	4.143	6.800	
Total	5.204	4.248	4.637	5.553	3.491	5.160	5.731	4.977	5.798	
Orissa										
Jute	6.962	6.905	7.000	7.455	7.308	9.095	7.035	7.085	7.658	8.617
Mesta	3.769	4.800	5.000	5.241	5.613	5.038	4.861	4.757	5.432	
Total	5.897	6.119	6.233	6.575	6.675	7.544	6.194	3.679	6.560	
Tripura										
Jute	7.667	6.429	8.143	8.125	7.556	7.250	6.125	8.333	7.500	6.167
Mesta	5.461	6.286	6.125	6.111	5.500	5.700	5.455	6.111	6.000	
Total	6.520	6.357	7.067	7.059	6.474	6.389	5.737	7.000	6.562	
Andhra Pradesh										
Mesta	4.541	3.115	3.233	3.402	3.396	4.139	4.093	5.955	5.989	
Uttar Pradesh										
Jute	8.250	8.000	7.818	7.923	8.500	8.800	8.778	8.333	5.111	9.000
All India										
Jute	7.182	5.562	7.363	6.593	6.974	7.111	7.844	6.733	7.564	7.235
Mesta	3.963	3.236	3.509	3.803	3.885	3.795	3.827	4.270	4.357	
Total	6.321	4.755	6.225	5.740	6.151	6.133	6.600	5.934	6.446	

(The above figures have been computed from Tables 1 and 2.
(One acre equals to 0.405 hectare)

Table 6 : Matrix Showing Cost Variations of Jute Per Quintal at Different Levels of Productivity Per Acre

Cost of production→ / Items of cost ↓		Production of jute in quintals					
		4	5	6	7	8	9
Variable Costs							
Human labour		526.88	658.60	790.32	922.04	1053.76	1185.48
Bullock labour		80.44	100.55	120.66	140.77	160.88	180.99
Seeds		12.08	15.10	18.12	21.14	24.16	27.18
Fertilizers and manures		40.52	50.65	60.78	70.91	81.04	91.17
Plant protection chemicals		8.16	10.20	12.24	14.28	16.32	18.36
Depreciation of implements		33.00	41.25	49.50	57.75	66.00	74.25
		701.08	876.35	1051.62	1226.89	1402.16	1577.43
Marketing charges		44.00	55.00	66.00	77.00	88.00	99.00
		745.08	931.35	1117.62	1303.89	1490.16	1676.43
Fixed Costs							
Irrigation	11.53						
Land revenue and Irrigation tax	5.69						
Interest on capital	633.84						
Management	480.00						
Miscellaneous	21.75						
	1142.81	1142.81	1142.81	1142.81	1142.81	1142.81	1142.81
Total Costs		1887.89	2074.16	2260.43	2460.70	2632.97	2819.24
Cost per quintal (Rs.)		471.97	414.83	376.74	349.53	329.12	313.25

The above figures have been computed from Table 3

Table 7 : Matrix showing Cost Variations of Mesta per Quintal at Different Levels of Productivity per Acre

Cost of production→		Production of Mesta in Quintals				
Items of cost ↓		3	4	5	6	7
Variable Costs						
Human labour		376.89	502.52	628.15	753.78	879.41
Bullock labour		73.47	97.96	122.45	146.94	171.43
Seeds		18.36	24.48	36.60	43.92	42.84
Fertilizers and manures		21.96	29.28	36.60	43.92	51.24
Plant protection chemicals		3.93	5.24	6.55	7.86	9.17
Depreciation of implements		8.28	11.04	13.80	16.56	19.32
		502.89	670.52	838.15	1005.78	1173.41
Marketing charges		32.52	43.36	54.20	65.04	75.88
		535.41	713.88	892.35	1070.82	1249.29
Fixed Costs						
Rent	4.00					
Interest on capital	229.40					
Management	480.00					
Miscellaneous	8.00					
	721.40	721.40	721.40	721.40	721.40	721.40
Tota lCosts		1256.81	1435.28	1613.75	1792.22	1970.69
Cost per quintal (Rs.)		418.94	358.82	322.75	298.70	281.53

The above figures have been computed from Table 4.

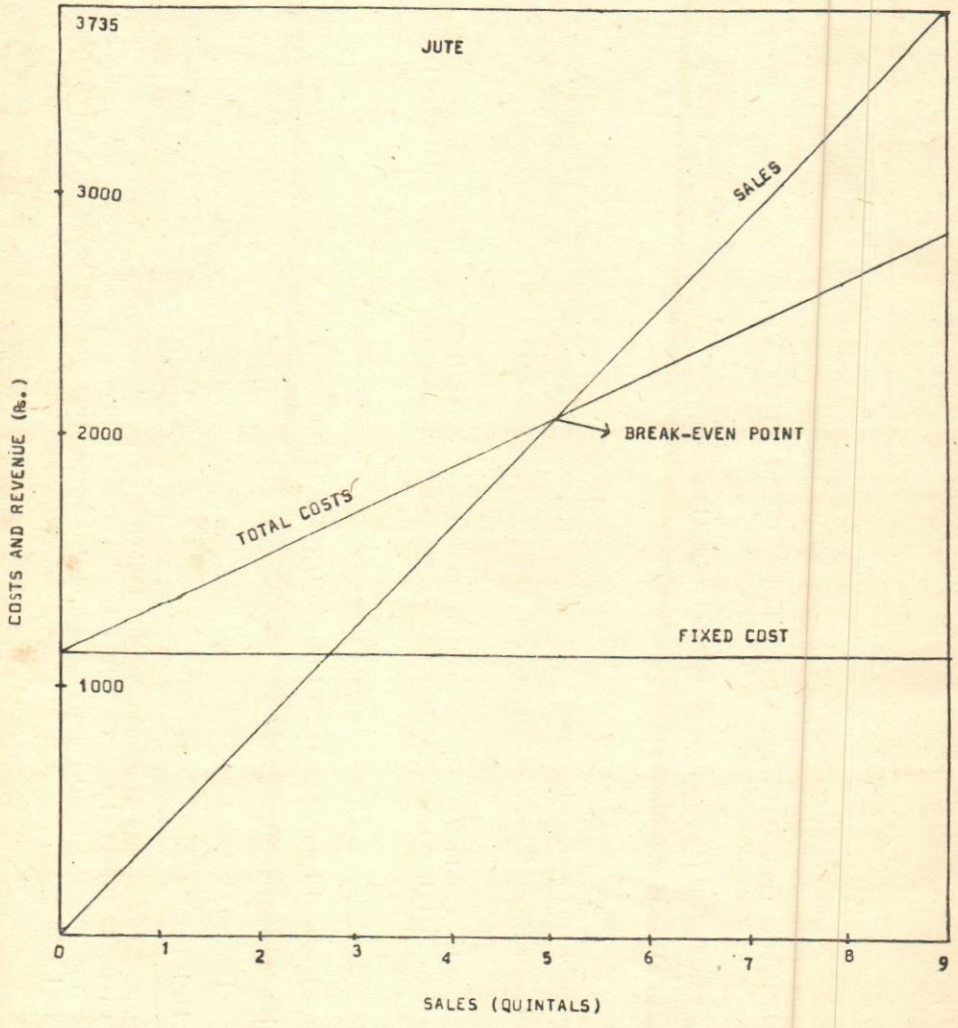
Table 8 : Deficiency in Calculations of Directorate of Economics and Statistics

Sl. No.		Cost in respect of the item in column (2) as taken by West Bengal Government (Rs. per acre)
1.	Instead of interest on the cost of land (part of capital) the Directorate takes a token rental value of the land	623.84
2.	The cost of transportation to primary market is not included in the data	6.58
3.	There is no provision for rejection of jute by the purchaser	3 92
4.	There is no provision for cost oft soring the jute	5.60
5.	There is no provision for supervisory cost	480.00
6.	There is no provision on account of 'hazards' which have very often to be faced by jute cultivators	-
7.	There is no provision for interest on borrowings by the cultivators from private money-lenders. (This item is only deemed to be covered as part of cash and kind expenses).	(Included in item 1 above)
8.	The cost of human labour and bullock labour has been shown at a very low scale (Rs. 530)	997.49
9.	There is very low provision for cost of pesticides (only 71 paise per hectare)	2.00
10.	Depreciation on implements is provided for on a very low scale	51.98
11.	No provision is made for cost of packing	-
12.	Cost of irrigation provided is too low (Re. 1)	11.53

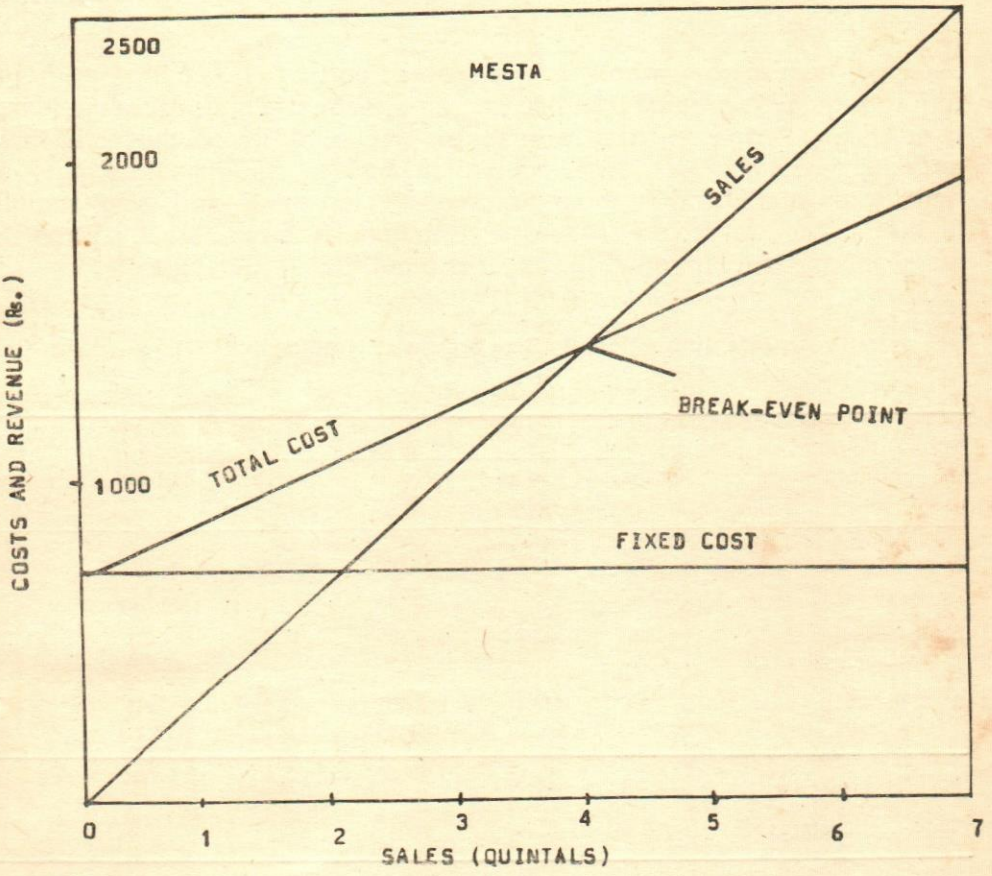
(Incidentally, these figures have all been included in Table III).

Committee on Public Undertakings (1977-78) (Sixth Lok Sabha), Eighth Report on Jute Corporation of India Limited, (Government's Unfair Pricing Policy for Raw Jute), (Ministry of Industry), Lok Sabha Secretariat, New Delhi, April 1978. p. 11.

Break Even Chart I



Break-Even Charat II



(On the basis of figures presented in Tables 6 and 7, break-even charts have been drawn indicating the break-even points. 10 percent margin on cost of production has been assumed for determining sales revenues. It has been further assumed that the entire production has been sold at the same price. The charts broadly indicate the profitability paths above the break-even point and the levels of production which have to be attained for recovery of fixed costs).

APPENDIX

Jute is grown almost wholly in the eastern part of the country aggregating to a modest area of 8,54,000 hectares, essentially under unirrigated conditions. Irrigated area represents just one-fifth of the total area under jute cultivation. Jute cultivation in the country is largerly an activity of small and marginal holdings. The small and semi-medium holdings account for a little over one-half of the total area; and the marginal and sub-marginal for another one-fifth.

Jute Cultivation By Size Groups of Holdings, 1970-71

(Area in 000 hectares)

Sl. No.	Size-Group	Area				Total	Percentage
		Irrigated	Percentage	Unirrigated	Percentage		
1.	Less than 1.0 hectares	32 (19.5)	19.4	133 (19.4)	80.6	165 (19.4)	100.0
2.	1-0 - 2.0 hectare	70 (42.7)	29.7	166 (24.2	70.3	236 (27.8)	100.0
3	2-0 - 4.0 hectares	29 (17.7)	13.4	187 (27.2)	86.6	216 (25.4)	100.0
Sub Total	1.0 - 4 0 hectares	99 (60.4)	21.9	533 (51.4)	78.1	452 (53.2)	100.0
4.	4.0 - 10.0 hectares	20 (12.2)	12.5	140 (20.4)	87.5	160 (18.8)	100.0
5.	10.0 hectares and above	13 (7.9)	17.8	60 (8 8)	82.2	73 (8.6)	100.0
	All Groups	164 (100.0)	19.3	686 (100.0)	80.7	850 (100.0)	100.0

All India Report on Agricultural Census, 1970-71, Ministry of Agriculture and Irrigation, (Department of Agriculture), Government of India, New Delhi, 1975, p. 39. □

Growth Performance of Punjab Agriculture (1950-51 to 1974-75): An Analytical Study

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Whereas it is common knowledge that Punjab is one of the most progressive agricultural states, there is little empirical evidence on the nature and pace of its growth performance. There is also insufficient evidence on how the relative contribution of different components to agricultural growth has varied over time. This study was, therefore, undertaken to examine the growth performance in Punjab agriculture for two periods, pre-green revolution period from 1950-51 to 1965-66 and post-green revolution period from 1965-66 to 1974-75.

Specifically, the objectives of the study were :

i) to estimate the compound growth rates of area, production and yield for selected crops; and

ii) to examine the contribution of different components to agricultural production and productivity.

Methodology

Data on production, prices, yield and acreage of important crops grown in the Punjab State i.e. wheat, gram, maize, paddy, sugarcane and American cotton were obtained from Statistical Abstracts, Punjab.

Compound growth rates for area, production and yield for the pre-green revolution period from 1950-51 through 1965-66 were taken from an earlier study on 'Agricultural Growth Rates in the Punjab, conducted by the Department of Economics and Sociology, Punjab Agricultural University, Ludhiana in 1968[1]. Compound growth rates for the post-green revolution period from 1965-66 through 1974-75 were calculated by the authors. These compound growth rates were worked out both at the state and the district level. The data were properly adjusted in relation to the change in district boundaries both in the pre-green revolution period because of merger of PEPSU with Punjab on the eve of re-organi-

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sation of states in 1956 and also in the post-green revolution period because of the division of Punjab in 1966 and the creation of Faridkot district in 1972.

The compound growth rates of area, production and yield were calculated by the least squares method of fitting the exponential function $Y = AB^x$ where Y is the variable for which growth rate is calculated and x is the time, $B = 1 + r$ where r is the compound growth rate. The standard errors of the growth rates were found by using the formula :

$$SE(r) = \frac{100\ B}{Log_{10}^{e}} \sqrt{\frac{\left[\Sigma(\log y)^2 - \frac{(\Sigma \log y)^2}{N}\right] - \left[\log_{10} B\right]^2 \left[\Sigma X^2 - \frac{(\Sigma X)^2}{N}\right]}{(N-2)\left[\Sigma X^2 - \frac{[\Sigma X]^2}{N}\right]}}$$

Student's 't' test was applied to examine the significance of the growth rates.

Since increases in production are the net result of the changes in acreage, yield and cropping pattern, it was considered important to examine how the relative contribution of these factors has changed from the pre-green revolution period to the post-green revolution period. For this purpose the Minhas-Vaidyanathan Additive Model [2] was used for the post-green revolution period to compare the relative contribution of area, yield, cropping pattern and interaction of yield with cropping pattern for the second period with the first period for which the estimates were available under the previous study.

However, some recent studies have indicated that in addition to area, cropping pattern and yield, price structure is also an important factor which needs to be taken into consideration [3]. An attempt has also been made to decompose change in productivity and production to take care of price structure as follows :

$$Y_1 - Y_o = \triangle Y = \Sigma a_c^{\circ}\, y_c^{\circ}\, \triangle p + \Sigma a_c^{\circ} p_c^{\circ} \triangle y + \Sigma y_c^{\circ}\, p_c^{\circ} \triangle a + \Sigma a_c^{\circ} \triangle p\, \triangle y + \Sigma y_c^{\circ}\, \triangle a \triangle p + \Sigma p_c^{\circ} \triangle a \triangle y + \Sigma \triangle a \triangle y \triangle p \quad \ldots \quad \ldots \quad (1)$$

$$Q_1 - Q_o = \triangle Q = A^1 Y^1 - A^{\circ} Y^{\circ} = (A^1 - A_o)\Sigma a_c^{\circ}\, y_c^{\circ}\, p_c^{\circ} + A^1 \Sigma a_c^{\circ}\, y_c^{\circ}(p_c^1 - p_c^{\circ}) + A^1 \Sigma\, a_c^{\circ}\, p_c^{\circ}\, (y_c^1 - y^{\circ}) + A^1 \Sigma y^{\circ} p^{\circ} (a^1 - a^{\circ}) + A^1 \Sigma a_c^{\circ}\, (y_c^1 - y^{\circ}) + (p_c^1 - p_c^{\circ})\ A^1\, \Sigma y_c^{\circ}\, (a_c^1 - a_c^{\circ})\ (p_c^1 - p_c^{\circ}) + A^1 \Sigma p_o^{\circ}\, (a_c^1 - a_c^{\circ})\ (y_c^1 - y_c^{\circ}) + A^1 \Sigma\, (a_c^1 - a_c^{\circ})\ (y_c^1 - y_c^{\circ})\ (p_c^1 - p_c^{\circ})$$

where y_c=yield of c^{th} crop, a_c=proportion of gross cropped area of c^{th} crop, p_{cr}=current price of c^{th} crop, Y=level of productivity in value terms, A_c=gross area under c^{th} crop, Q=gross agricultural output in value terms, Q_c=physical output of c^{th} crop, p_c=deflated price of c^{th} crop. The superscripts ° and ' refer to the base and current periods.

Decomposition of productivity in equation (1) gives us effects of price, yield, cropping pattern, interactions of price and yield, cropping pattern and price, cropping pattern and yield and the interaction of cropping pattern, yield and price structure. Decomposition of production gives us area effect in addition to the other terms.

Results and Discussion

Table 1 presents the compound growth rates of area, production and yield for selected crops for the two periods 1950-51 to 1965-66 and 1965-66 to 1974-75 for Punjab State. It would be seen that the growth rates of area increased significantly for paddy and wheat with those two crops emerging as a dominant rotation particularly in areas provided with assured irrigation in Punjab. There was a deceleration in the growth rates in area under maize and American cotton. Sugarcane and gram experienced negative growth rates in the second period.

It would also be seen from the above Table that the sharpest increases in growth rate in production were recorded by paddy, wheat and sugarcane in that order. There was a deceleration in growth rates of production of maize and American cotton and a negative growth rates of production of gram over the period.

The sharpest growth rates for yield took place for sugarcane, gram, paddy and wheat. It would be seen that the yield breakthrough for sugarcane made it possible to record a compound growth rate of 10.07 on production in spite of a negative growth rate of 5.03 in area for second period. But the negative growth rate of area under gram was huge enough to more than swamp and sharp positive growth rate of yield for the second period resulting in a negative growth rate of production for this crop. The sharpest increase in production of paddy and wheat over the post-green revolution period were made possible by increased relative

profitability of these crops which caused a shift in the cropping pattern in favour of these crops.

Tables 2, 3 and 4 present the district-wise picture of area, production and yield of selected crops during the two time periods. It would be seen that there have occurred significant shifts in this growth rates of production of some important crops which in turn are due to ths sharp increases in yields made possible by sustained research for the evolution and adoption of high-yielding variety crops coupled with increased use of complementary inputs like chemical fertilizers, weedicides, etc., on areas provided with assured irrigation. The extension agencies have also played crucial role in extending the results of the biological and chemical innovations to the farmer's fields.

The sharpest growth rate of area for paddy were recorded for Ludhiana followed by Jullundur, Ferozepur and Patiala during the post-green revolution period. In case of maize, the sharpest growth rate of area was recorded for Jullundur, followed by Ludhiana and Sangrur; for wheat the sharpest growth rates were recorded in Sangrur, Bhatinda, Kapurthala and Ferozepur, sugarcane, bajra and gram recorded negative growth rates during the post-green revolution period. American cotton recorded positive growth rate of 9.10 percent and 5.30 percent both for Bhatinda and Ferozepur districts during the post-green revolution period.

The sharpest growth rates in production of paddy period-II were recorded for Ludhiana, Jullundur, Ferozepur, Patiala, Ropar, Kapurthala, Hoshiarpur, Gurdaspur and Amritsar in that order, while for maize the highest growth rates were estimated for Bhatinda, Sangrur, Kapurthala Ropar, Hoshiarpur, Ludhiana and Gurdaspur. The most spectacular growth rates were recorded for wheat production for Hoshiarpur, Ropar Sangrur, Patiala, Jullundur, Ferozepur and Amritsar. Despite a general decline in the growth rates of area under sugarcane, bajra and gram, some districts did record increase in production under these crops. Sugarcane recorded growth rates of 6.90 for Ropar, 6.40 for Gurdaspur, 5.90 for Kapurthala and 3.50 for Sangrur over the post-green revolution period. Similarly, bajra recorded a growth rate of 28 40 percent in Kapurthala, 6.90 percent for Bhatinda, 1.80 percent for Ferozepur and 1.30 percent for Gurdaspur and gram recorded a growth rate of 10 10 percent for Hoshiarpur and 7.84 percent for Bhatinda and 0.60 percent

for Ropar. American cotton showed positive growth rates of production for the post-green revolution period for Bhatinda (12.10) Sangrur (0.40%), Ferozepur (8.80%) and Amritsar (1.40%) over the post-green revolution period.

Coming to an analysis of the compound growth rates of yield for the selected crops, it would be seen that the sharpest growth rates were recorded for rice in Ludhiana, Bhatinda, Ropar, Jullundur, Sangrur in the post-green revolution period, whereas the growth rates for rice yield were highest for Patiala, Sangrur and Kapurthala districts in the pre-green revolution period. This is because of the fact that Ludhiana, Bhatinda and Ropar which were not paddy growing areas in the pre-green revolution period adopted this Kharif enterprise in a big way in the post-green revolution period due to the increased availability of assured irrigation facilities against the back-drop of phenomenal yields realisable from high-yielding varieties of this cereal crop. The growth rates of yield were particularly high in these districts during the post-green revolution period as they started almost from a scratch. Jullundur, Sangrur, Patiala, Ferozepur and Kapurthala experienced relatively lower growth rates of yield as this crop was already grown in these districts and the existing levels of yield were fairly high. For maize, the growth rates of yield were the highest for Gurdaspur followed by Amritsar and Kapurthala over the same period. Wheat recorded the sharpest growth rate of productivity for Patiala (15.60), followed by Hoshiarpur (10.80), Sangrur (8.10), Jullundur (7.10), Gurdaspur (6.80), Ropar (6.00), and Bhatinda (5.00). Sugarcane recorded the highest growth rates of yield for Bhatinda (10.90), Ropar (8.80), Patiala (8.00), Kapurthala (6.80), Gurdaspur (6.60), Hoshiarpur (6.30), Jullundur (6.00) and Amritsar (5.80). Similarly, American cotton recorded the highest productivity gains for Amritsar (7.30), Ropar (5.80), Sangrur (4.70). Bajra showed the highest growth rates for Kapurthala (16.20) followed by Hoshiarpur (8.10), Patiala (7.80) and Gurdaspur (6.80). Gram indicated the highest growth rate of Hoshiarpur and Ludhiana (12.70) followed by Gurdaspur (11.50).

The decomposition of the relative contribution of different factors to foodgrain production through the Minhas-Vaidyanathan model for the post-green revolution period is depicted in Table 5 along with the results already available for the pre-green revolution period. It would be seen that whereas in the pre-green revolution period, acreage contribution was 45.71 percent and yield contribution 17.38 percent, in the

post-green revolution period, the roles seem to have been reversed with yield effect contributing 50.70 percent and the acreage merely 12.34 percent. Further, as price has been identified as an important factor contributing to changes in value product per hectare, the decomposition was also attempted by taking this factor into consideration in addition to area, yield and cropping patterns.

The results of this analysis are presented in column 2 of Table 6 which indicates that in the decomposition of increase in value product per hectare, price structure, interactions of price and yield, cropping pattern and price, cropping pattern, yield and price made negative contributions. However, yield and cropping pattern made significant positive contributions to value productivity per hectare and their interaction was also strong and positive which contributed 14.06 percent to value produce per hectare.

However, decomposition of value product per hectare is a partial analysis in as much as it conceals the area contribution. So, an attempt was also made to decompose the increase in the value of output of crops considered in this analysis and the results are indicated in column 3 of Table 6. It would be seen that the value of crop output increased by Rs. .2596 million over the period. Out of this increase, 20.79% was contributed by area, 72.23% by yield, 10.85% by shift in the cropping pattern and 11.13% by the interaction of cropping pattern and yield. Price structure, interaction of yield and price structure, cropping pattern and price structure and the combined interaction of cropping pattern, yield and price structure made negative contribution to the extent of 5.69%, 8.81%, 0.46%, and 1.04% respectively.

Conclusion

From the foregoing analysis it can be concluded that there have been significant changes in the compound growth rates of area, production and yield of the selected crops from the pre-green revolution period to the post-green revolution period. Due to the technological breakthrough paddy-wheat rotation has become a dominant crop rotation of Punjab. The decomposition of agricultural production and productivity has revealed that there has occurred a sharp shift in the relative roles of yield and area in particular with the yield assuming the role of a dominant

contributor to the increase in production and productivity in the post-green revolution period as compared to area which played a prominent role during the pre-green revolution period. Further, the more detailed decomposition of production and productivity revealed that price structure has been making a negative contribution which points to the urgency for reorienting agricultural production and price policies for regulating the cropping pattern in favour of more-remunerative crops and/or providing price support for the less remunerative crops if their production is to be maintained in social interest.

Table 1

Compound Growth Rates of Area, Production and Yield of Selected Crops in the Punjab State, 1950-51 to 1965-66 and 1965-66 to 1974-75

Crops	*Area*		*Production*		*Yield*	
	Period I 1950-51 to 65-66	*Period II 1965-66 to 74-75*	*Period I 1950-51 to 65-66*	*Period II 1965-66 to 74-75*	*Period I 1950-51 to 65-66*	*Period II 1965-66 to 74-75*
Rice	6.375***	8.20***	9.131***	18.40***	2.56***	9.20***
Maize	3.93***	3.40***	6.20***	3.70***	2.235NS	0.20NS
Wheat	3.22***	4.80***	5.48***	11.20***	2.19***	6.10***
Sugarcane	4.08***	—5.03***	6.224***	10.07***	1.22NS	10.62***
American cotton	8.53**	4.40***	9.23***	7.60***	1.74***	3.10***
Bajra	—2.484***	2.98*	0.02NS	2.06NS	2.67NS	1.40NS
Gram	3.385**	—8.30***	3.735NS	—5.86**	0.19NS	10.27***

*Significant at 10 percent level
**Significant at 5 percent level
***Significant at 1 percent level
NS stands for not significant

Table 2

Compound Growth Rates of Area of Selected Crops in Different

Crops/Districts	Rice		Maize		Wheat	
	1950-51 to 65-66	*1965-66 to 74-75*	*1950-51 to 65-66*	*1965-66 to 74-75*	*1950-51 to 65-66*	*1965-66 to 74-75*
Ludhiana	—	19.20*	5.11†	7.20†	3.31†	5.60†
Bhatinda	—	—11.30NS	—	—8.40†	4.435†	4.20↓
Ropar	—	3.60↓	—	3.60†	—	6.80†
Kapurthala	11.18†	6.20†	4.96†	0.60NS	2.67†	3.50†
Ferozepur	2.93†	10.80†	7.38†	—7.10†	2.21†	2.70*
Jullundur	15.705†	19.00†	4.44†	13.80†	2.04†	1.50†
Hoshiarpur	5.98†	4.60†	1.095↓	4.10†	—0.145NS	4.70†
Sangrur	15.63†	9.60↓	3.35†	6.0↓	3.53†	4.70†
Patiala	11.85†	10.40†	0.78NS	2.50†	3.67†	3.89†
Gurdaspur	4.305†	5.00†	0.97NS	1.90†	1.055NS	1.80NS
Amritsar	7.025†	6.60†	3.03†	—1.63NS	1.29†	5.30†

*Significant at 10 percent level

↓Significant at 5 percent level

†Significant at 1 percent level

Districts of Punjab State Through 1950-51 to 1965-66 and 1965-66 to 1974-75

Sugarcane		*Cotton Am.*		*Bajra*		*Gram*	
1950-51 to 1965-66	*1965-66 to 74-75*	*1950-51 to 65-66*	*1965-66 to 74-75*	*1950-51 to 65-66*	*1965-66 to 74-75*	*1950-51 to 65-66*	*1965-66 to 74-75*
3.355†	—6.70†	—	—10.20†	—	0.20^{NS}	—2.943†	— 17.60†
—	—7.50↓	—	9.10†	0 968^{Ns}	— 3 70↓	1.63^{NS}	—7.60↓
—	1.50^{NS}	—	- 27.50†	—	—	—	- 2.90†
—	—8.20†		— 14.20†	—	— 25.70↓	—4.772^{NS}	- 27.20↓
—	—3.70^{NS}	—	5.30†	—	— 3.40*	— 3.264†	—7 40†
1.954†	— 4.45†	—	3 00^{NS}	—	— 9.40*	—0.543^{Ns}	—28.90†
—0.761^{NS}	— 3.20*		—11.20↓		—18.90†	0.09^{Ns}	—0 40↓
3.38†	— 2.43^{NS}	—	0.10^{NS}	—3.165†	- 3.62^{NS}	—0.991^{NS}	—9.62†
5.475†	—7.40†	—	- 11.63†	—	—5.86^{NS}	6.76†	— 7.26†
1.78↓	—0.98^{Ns}	—	—16.55†	—	4.40^{NS}	1.55^{NS}	—12.04†
0.13^{NS}	—7.08†	—	- 5.42↓	—	—1.58^{NS}	—3.674†	—16.40†

Table 3

District-wise Compound Growth rate of Production of Different Crops in the Punjab through 1950-51 to 1965-66 and 1965-66 to 1974-75

District	Rice		Maize		Wheat		Sugarcane		Am. Cotton		Bajra		Gram	
	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75
Ludhiana	—	39.30†	9.06	4.40†	7.025†	9.40†	4 84†	—21.20*	—	—9.20*	—	—3.20NS	—1.816NS	—16.20†
Bhatinda	—	—10.10NS	—	5.80*	7.68†	9.60**	—	—2.60NS	—	12.10†	—0.694NS	8.90**	1.56NS	7.94NS
Ropar	—	18.40†	—	4.50*	—	14.00**	—	6.90NS	—	23.50*	—	—	—	0.60NS
Kapurthala	16.335†	16.40†	2.78NS	4.80NS	2.765NS	6.60**	—	5.90**	—	—7.40*	—	28.40NS	—4.508NS	—19.10NS
Ferozepur	3.185**	22.80†	5.93**	—5.80NS	3.40**	11.10**	—	—10.70†	—	8.80†	—	1.80NS	—3.239NS	—6.30*
Jullundur	4.45**	31.80†	6.37†	2.80NS	4.035†	12.60†	2.74**	1.40NS	—	—17.10†	—	—14.20NS	0.515NS	—14.00**
Hoshiarpur	4.45**	14.80†	7.93**	4.40NS	0.345NS	15.80†	—	1.90NS	—	—9.20NS	—	—7.60NS	—2.134NS	10.10*
Sangrur	17.835†	3.85†	2.54NS	6.30†	6.34†	13.20†	6.125†	3.50NS	—	10.40NS	—1.698NS	—0.50NS	2.695NS	—8.7†2
Patiala	19.84†.	21.00**	1.61NS	3.30**	7.33†	12.70†	4.595†	—0.03NS	—	—10.42†	—	0.70NS	7 195**	—8.59**
Gurdaspur	2.81NS	13.60†	3.22NS	4.20NS	2.095NS	9.50†	4.53†	6.40†	—	—10.56†	—	1.80NS	—0.795NS	—1.17NS
Amritsar	5.33†	12.70†	3.62NN	3.50NS	3.555†	10.40†	2.263NS	—2.34NS	—	1.40NS	—	—1.49**	—1.853NS	—15.11†

*Significant at 10 percent level
**Significant at 5 percent level
†Significant at 1 percent level
NS stands for not significant

Table 4

District-wise Compound Growth Rate of Yield of Different Crops in the Punjab through 1950-51 to 1965-66 and 1965-66 to 1974-75

District	Rice		Maize		Wheat		Sugarcane		American Cotton		Bajra		Gram	
	1950-51 to 1965-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 75-76	50-51 to 65-66	65-66 to 74-75	50-51 to 65-66	65-66 to 74-75	1950-51 to 65-66	65-66 to 74-75
Ludhiana	—	15.80†	3.23NS	0.20NS	3.54†	3.50**	1.193NS	4.70**	—	0.90NS	—	3.12NS	1.15NS	12.70NS
Bhatinda	—	14.90†	—	1.20NS	4.20†	5.00**	—	10.90NS	—	1.80NS	0.985NS	2.30NS	—0.148NS	2.50NS
Ropar	—	14.50†	—	0.80NS	—	6.00**	—	8.80**	—	5.80NS	—	—	—	3.80NS
Kapurthala	6.57†	9.70†	—2.232NS	4.20**	—1.1585	3.00NS	—	6.80†	—	2.00NS	—	16.20**	—1.735NS	3 00NS
Ferozepur	1.85NS	11.10†	—1.091NS	—3.70NS	0.92NS	4.70**	—	1.00NS	—	2.40†	—	5.60**	0.04NS	0.90NS
Jullundur	1.70NS	11.20†	1.86NS	—1.60NS	2.07**	7.10†	1.052NS	6.00†	—	0.20NS	—	—6.40**	—	7.80**
Hoshiarpur	0.155NS	7.10NS	6.39†	0.20NS	0.42NS	10.80†	—	6.30NS	—	2.50†	—	8.10NS	—2.188**	12.70NS
Sangrur	7.003†	11.10†	0.83NS	—0.18NS	2.71†	8.10†	2.19NS	6.10**	—	4.70†	1.32NS	3.90NS	0.92NS	0.90NS
Patiala	8.75†	0.51†	0.56NS	0.20NS	3.35†	15.60**	—0.161NS	8.00†	—	1.80NS	—	7.80NS	0.54NS	—1.55NS
Gurdaspur	0.09NS	8.50†	2.19NS	5.20**	1.08NS	6.80**	2.648†	6.60**	—	2.80**	—	6.80**	—0.64NS	11.50*
Amritsar	—0.741NS	5.60†	2.445NS	5.00NS	2.245**	4.70**	2.97†	5.80**	—	7.30†	—	1.30NS	1.79**	1.90NS

*Significant at 10 percent level
**Significant at 5 percent level
†Significant at 1 percent level
NS stands for not significant

Table 5

Percent Contribution of Different Factors to Total Increased Food Grains Production in Punjab through 1951-52 to 1964-65 and 1965-66 to 1974-75

Variables	*1951-52 to 1964-65*	*1965-66 to 1974-75*
Acreage	45.71	12.34
Yield	17 38	50.70
Croad Pttern	34.33	17.26
Interaction	2.53	19.72

Table 6

Relative Contribution of Different Factors in the Growth of Productivity and Production

Effects	*Productivity*	*Production*
Individual effects		
Area	—	20.79
Price structure	—7.18	— 5.69
Yield	92.45	73.23
Crop pattern	13.70	10.85
Interaction effects		
Crop pattern yield	14.06	11.13
Yield & price structure	—11.13	8.81
Crop pattern & price structure	—0.58	—0.46
Yield, crop pattern and price structure	— 1.31	—1.04

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Book Reviews

Consultancy Services in the U.S.A., Canada, India

I. Moses

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Reviewed by S. A. Khader*

This publication is the outcome of a study sponsored by Federation of Indian Export Organisations, New Delhi (FIEO). The study was aimed at providing insight into working methods of consultancy organisations in the USA and Canada and comparing the same with that of Indian institutions for beneficial ends and developing guidelines for extending our consultancy services to the developing world. FIEO selected no less a person than Irudianathan Moses of ASCI, a well-known figure in Management Consultancy, for taking up the study tour of these countries.

In contrast to the situation abroad, Moses finds that this profession of consultancy in our country has neither created the desired impact nor achieved the trust and professional integrity it should have. He points out that disciplined approach and professional competence of the consultants and their organisations would only be able to establish the profession of consultancy in a developing economy like ours. There is a great need to ascertain that the consultants and consultancy organisations work either with certain self-imposed discipline and professional integrity or they are controlled by certain regulatory agencies to maintain and uphold the professional excellence. The publication also outlines in brief the philosophy and working of two voluntary regulatory bodies like Association of Consulting Management Engineers of America (ACME) and Canadian Association of Management Consultants (CAMC). These agencies are instrumental in maintaining high professional standards through periodic review of membership and subjecting the Consultancy organisations to a strict code of professional conduct and practice. When the ever-increasing number of free-lance consultants and consultancy firms in our country are controlled through a regulatory agency, only then this profession of consultancy will be well received by our entrepreneurs and managers. One such voluntary agency in the name of Management Consultants Association of India (MCAI) has come into vogue in Bombay. Possibly, an Association having national

* Deputy Director, National Productivity Council, Chandigarh

standing with certain statutory powers may be able to provide better service to the profession of consultancy.

The other aspect equally stressed by Moses is the need for improving the professional calibre of our consultants both in technical and managerial skills, if we are to be successful in other countries. He identified that right type of training of consultants should assume vital importance in the growth and development of this profession. In the light of his observations in the USA and Canada, he goes on to outiine the nature and mode of training to be given to an individual in shaping him up as a professional consultant. Existence of the locally-developed 2-year consultant development programme of the National Productivity Council, New Delhi, in the areas of Industrial Engineering, Fuel Efficiency, Behavioural Sciences, Plant Engineering, Financial Management, Marketing Management and Agricultural Productivity would be of interest in this context. The study brings out a host of other recommendations that would go a long way in making the consultancy profession more useful and acceptable in our endeavours.

We have been largely successful in exporting our industrial goods and agricultural produce. It is in the fitness of things that we also try to extend our services in the form of technical and managerial consultancy services to the developing world. This step of FIEO, in initiating a study of this nature and its findings through this report would enable our consultancy organisations to develop themselves to meet the expected professional standards and take up joint as well as independent ventures in other countries. □

Project Formulation in Developing Countries

P. K. Mattoo

Macmillan Company of India Ltd., New Delhi, pp. 268, Rs. 30.00

Reviewed by Ram Prakash*

Project selection is regarded as a vital process in the success of development Plan. Draft Five Year Plan (1978-80) and various reports

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of the Committees on Public Undertakings emphasise that inadequate initial planning of projects had led to wrong investment decisions. In this context, this book dealing with all aspects of project formulation from the stage of identification to its final presentation in a form facilitating investment decisions, could justly claim to be of topical interest. The author correctly mentions "very little guidance and literature on the subject are available". Probably, he means, in a comprehensive and compact form. The author through this book "seeks to fill this void".

Project formulation, according to the author, is an investigating process which precedes investment decision. The preparation of Detailed Project Report is rightly regarded as "the work of different nature and magnitude from Pre-Investment Report". The book, among others, has discussed the technique of PERT/CPM in nearly one-fourth of the total number of pages. PERT/CPM is commonly accepted as a tool of Implementation Planning—a stage following after pre-investment decision. A reader may justly differ with the author on his decision to include this technique within the scope of the book. In describing various components of Feasibility Report and different techniques, one important omission is Project Location and the manner in which it is decided. The procedure to determine the requirements of cash over the life of the project are described under Cash Flow Statement rather than under the commonly-used term Liquidity Statement. The book advocates use of Discounted Cash Flow Techniques for assessing the investment worthiness of a project, but skips over description of various known short-cut methods of calculating IRR. At many places, the book gives an impression of undigested financial concepts. For instance, in the application of techniques of Net Present Value and Internal Rate of Return, financial experts do not take depreciation as an item of expense for reason to avoid double counting. This book in its check list, prepared to explain the mechanics of Liquidity Analysis and DCF techniques, mentions depreciation as an item of cost. The generalised conclusion made "The social costs of the project are in reality less than the financial costs" is true only in a limited sense. In fact, foreign exchange component is likely to enhance the cost of project from social point of view. The author rightly advocates need for rigorous analysis and critical examination of different components of feasibility report without mentioning the effective project design criteria. Illustration of all the tests of effective project design, viz., measurability, feasibility,

On the whole, the book is a good introductory reading and a poineering attempt in the development of management aid for project formulation. Two merits of the book are the exhaustive list of references for additional reading and the low price. □

Management By Motivation

Saul W. Gellerman

Taraporevala Publishing Industries Pvt. Ltd., Bombay, in arrangement with American Management Association, Inc., 1977, Price Rs. 38.00

Reviewed by P. Chattopadhyay*

Motivation and Productivity, by the same author, published some years ago and brought out in an Indian edition, attracted a good deal of notice both in academic and in industrial circles the world over. Unfolding the characteristics of human behaviour in productive circumstances and the factors that motivate human beings towards greater effort and achievement, the author did in that volume open up several new approaches to the question of improvement of performance. Motivation theory at ad

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The author makes a strong plea that application of behavioural science knowledge to organisations can usually be accomplished best through

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wiser and more imaginative administration in the main, while use of the sophisticated techniques of behavioural research and development is not discarded. In this respect the author emphasises that behavioural science involves application of techniques which demand a detailed understanding of social and psychological processes and as such be left under the care of the professional behavioural scientist Such application of behavioural science techniques by quacks may not only spoil the broth but may also create lasting dismemberment of individuals in contradistinction with the organic unity that an organisation must have for team effort. Indeed, such dangers have been widely noticeable and conclusions from similar situations have appeared widely different, confounding the confusion that exists. Even the subtle nuances of different motivation theories require close examination, appreciation and zealous, possibly meticulous, application. The ground is extremely delicate and the balancing act has to be performed with dexterity if success in the effort towards application of motivation theories in practice is aimed seriously.

The author does his job in fourteen chapters, covering some two hundred and seventy four pages, apart from the index which runs into another twelve pages. The organisational situation in which motivation has a significant role to play is delineated with reference to different problems faced over time in the first chapter which provides the setting of the book. The essence of motivation theory is explained in chapter two. The findings of some recent research on the subject are examined in chapter three in which the author underlines that motivation is a dynamic concept that changes all the time, usually too slowly to be noticed, usually fortuitously, sometimes for the worse; but sometimes it is changed deliberately and sometimes for the better. A behavioural explanation of the strategy of selection is presented in chapter four. He goes into really intricate problems of daily life of an executive. Just as war is too important to be left to the generals, selection is too important to be left in the hands of the experts, so he asserts. Management can and should control its own selection system. All this is easier said than done. However, he believes that first it must get rid of some of the prevalent illusions. indeed, these illusions are far too many and relate to different questions. The difficult art of choosing people, dealt with in chapter five, has several important things to say about the selectors and those selected. Different fallacies are pinpointed here to which selectors generally succumb without knowing it most of the time. For instance, the hero fallacy, the descriptive fallacy, the permanence fallacy and the fallacy of determinism. These

fallacies in different ways play their part in most organisations, private and public, and individuals either suffer or benefit from them depending on the situation in which they are placed. However, his pointer is highly significant that if a person has been found good for a certain purpose it is not necessary that he would be so for another. Even for the same purpose over time evaluation may vary widely because the individual may be good or very good at a point in time but not always necessarily. This creates problems of continuous evaluation for determining the suitability of individuals to jobs. Most of the time the managers consider themselves rather immune from such assessment and they remain busy prying into how others below are doing. The growing number of non-managers in managerial positions would attest the truth of this observation.

The context of enlargement of competence and the various theories and approaches that have been evolved to know and judge competence have been examined in chapter six of the study. He recommends that there are at least seven functions whose control should be centralised in the career management group. They relate to assessment of potentialities of managers for acquiring competence to handle heavier responsibilities, appraising performance; reviewing individual development plans and promotion plans for ensuring that stretching concept is being implemented judiciously yet without excessive timidity; scheduling, and helping superiors to prepare for career counselling; determining proper time for formal management training for each manager and the types of course content most suitable for him during each of his exposures to formal instruction; selection, training, assigning and varying management counsellors; and maintenance of an up-to-date, relevant and reasonably complete inventory of managers. Spotting the most-suited individuals to tasks calling for varying capabilities and developing them for the purpose have long remained the most demanding yet rather indifferently-handled areas. These enlisted functions warrant the utmost attention in an attempt to bridge the gap.

An important chapter in the book relates to predicting and measuring managerial performance. His distinction between selection and appraisal with reference to managerial performance is not only apt but significant; while the prediction of future performance is the essence of selection, that of appraisal is the evaluation of current performance. He ascribes four reasons why it is imperative to define effective managerial

performance more precisely. One, the principal ingredient of most management selection programmes is and will unduly continue to be nomination. He contests the very basis of this idea of nomination in the sense that it is absurd as a premise of managers who, because they are managers, somehow know how to identify potential managers. The frivolity of the long standing premise has been succinctly brought out. Two, most attempts to measure the effectiveness of selection systems in his view, have run into a sort of semantic sound barrier, going to the elusive nature of the things that selection systems are supposed to predict. Three, it is important to define managerial performance from the point of view of morale. The higher one goes in management, the more ambiguous the requirements of the job become, with the result that performance is not really measured so much as it is reviewed. Four, it is important to have a definition of effective performance in view of the fact that fixation of limits of acceptable and unacceptable behaviour imposes a sort of discipline on top management to stay within them, so that with their own judges more predictable, managers down below are less likely to be defensive. It should follow from this that the business of the organisation can then proceed in a more straightforward manner, with more emphasis upon results and less upon safety, popularity, and second-guessing the men at the top. The author brands morale as a spring which is neutral, indifferent and motionless. Relieving a negative pressure upon morale would mean that the *status quo ante* would be restored. It would require further effort to boost it to a level desired. This positive lead and the removal of negative pressure are discrete in his view and should be treated as such.

Loss of competence is the subject matter of chapter eight in which the author underlines that competence loss is not a well-studied, well-understood phenomenon. It is not the inevitable fate of anyone, in many cases it is indeed preventable. Age, he mentions, is no longer the advantage which once was, since education increasingly offsets experience and wisdom is often no match for being technically uptodate. He asserts that whenever a man's effectiveness declines sharply after some kind of blow to his self-esteem, to reassure him with that his future performance has not been prejudged would help him regain his poise. Failure to do this would be tantamount to writing off an asset that might otherwise have had considerable value. He makes the point that money can motivate exceptional accomplishments, first of all, by way of offering prospects of becoming wealthy and secondly by way of freeing the

individual of both real dependency and the tendency of others to suspect him of the tactics of dependency.

Analysing the theories propounded by Douglas McGregor, he asserts that Theory X and Theory Y were not simple devices for side-stepping the issue as to which managerial approach was right and which was wrong. In fact, they were not even opposites. Theory X denotes the more or less traditional set of assumptions about human nature on which management practices have been built since the Industrial Revolution enjoining that work was not a natural activity for most people, and that intelligent cooperation within an organised system was equally contrary to most men's instincts. In view of the fact that industry required both work and cooperation of its employees, theory X acted primarily through various ways of manipulating the economic dependence of the average employee upon his employer. He pleads for an appropriate approach, based on an examination of organisational realities rather than upon reactions of any kind. This approach was the essence of Theory Y, insisting that managerial strategies be based upon examination, not assumption, and that there were no eternal verities upon which management could rely so faithfully that a close examination of its own organisation became unnecessary. The defect in Theory X, according to him, lay not in its assumptions, but in its rigidity—its tendency to suggest that other approaches would not be appropriate, even in other circumstances. This is a revelation indeed and McGregor himself tried to explain the premises of his Theory X and Theory Y in his book, *The Professional Manager*. Unfortunately, this elaboration of the theories expounded earlier did not receive as much attention as these theories did. This aspect indeed deserves wide notice providing, as it does, a bigger handle for management practices.

While explaining the negative or demotivating aspects of budgets considered real and serious at times, he notes that budgets can, under certain circumstances, have a positive motivating effect leading to sustained improvement in performance provided that certain prerequisites are observed such as sensitive communication, effective participation and internalisation of goals. Coming to grips with organisational climates that make less than optimal use of available human resources is a gigantic problem but has a high potential payoff. Finding the right methods and making them work, therefore, hold the key. A good deal of emphasis comes naturally on organisational development stressing

clarification of roles, respecting tenets of group behaviour and group effectiveness. The last chapter deals with possible ways of handling the problems and the direction that organisations are struggling for in maximizing individual's contributions to the organisation and his satisfaction in belonging to it. The loose threads are far too many. While a good lot of them have been successfully tied up, several others call for organised, concerted action.

In all, this book has a wealth of material to commend itself for wide readership among managers, teachers, researchers and students of management and behavioural sciences. □

Personnel Management

P. C. Tripathi

Sultan Chand & Sons, New Delhi, 1978, pp. 270, Rs. 35.00

Reviewed by (Mrs.) B. Chopra*

The last decade has marked the beginning of an encouraging, though gradual, trend of Indianisation of management science by Indian scholars. There has been an increasing number of Indian publications over the last ten years, touching various aspects of management discipline, even though each of these publications cannot be said to have contributed to the Indianisation trend. But, the book under review is certainly a fairly successful attempt in this direction and the author deserves to be complimented for his efforts.

The book is an achievement of author's stated objectives of providing a text book on Personnel Management, and making it well balanced in theory and practice, incorporating mainly Indian personnel practices. And, it does meet both these objectives.

The book nearly follows the format of a standard foreign text book on Personnel Management and exposes various topics, though much more briefly, in broadly identical sequence. But, it makes its contribution in

*Managing Editor, *'Management and Labour Studies'*, Jamshedpur

terms of presenting each topic in Indian context. As a result, the contents of the book are a well-woven presentation of theory and Indian practice.

The presentation is in simple language; since the book has been written on the basis of the syllabi of personnel management courses in various universities, the content compared to that in any foreign text book is restricted and selective. However, almost all the important concepts from various areas like procurement, development, performance appraisal, wage and salary administration have been dealt with.

A discussion on evolution and growth of Personnel Management in India; the profession as it is understood and practised in India today—the extent of maturity or perfection the personnel practices possess or lack; the factors contributing to or impeding its growth; and on the future of the profession in this country makes the text meaningful and relevant. Reference to a number of Indian studies in the field further adds to the authenticity.

In the chapter 'Industrial Relations and Collective Bargaining', an attempt has been made to present a complete picture of legislative and voluntary framework of Indian industrial relations to facilitate readers' understanding. Some of the important legislations governing different aspects of labour-management relations have been introduced. This gives a rather clear idea about industrial relations status in India. Apart from such factual knowledge, the chapter also gives an evaluative and judgmental opinion about the Indian industrial relations scene, which perhaps the students should be encouraged to evolve themselves. On the whole, this chapter is well handled and is lucid in style.

Though there is an attempt to refer to recent studies for supplementary reading, yet, except for wage and salary administration, the references throughout seem to be predominantly restricted to literature published in 1960's. Perhaps a little more effort in this direction would have been very rewarding both for the author and the reader.

However, the book makes a good introductory text, and can be recommended to students at various universities. It can also be a good introduction for those middle level practitioners who have not been formally exposed to the subject. □

Manual on the Planning of Labour-Intensive Road Construction

Allal & G.A. Edmonds (in collaboration with A. S. Bhalla)

International Labour Organisation, Switzerland, 1977, pp. 254+xii, 40 Swiss Francs

Reviewed by J. D. Verma*

Road construction is one of those economic activities which have experienced the most rapid change of technology, with each stage becoming progressively more expansive than its predcessors. This is because of the fact that road development in any form, has become a vital ingredient of economic development programme besides being an equally-vital ingredient for the defence of a country. This has, therefore, prompted the Governments, particularly, those in the wealthy industrial countries to pour vast resources for perpetual advancement of road construction activity including construction of additional roads, maintenance and improvement of the existing ones. Accordingly, the developing countries which are often described as "Third World" have also to launch road construction programme in their respective countries to such an extent as would link all parts of the country so that the other programmes included in the national economic development plans get proper infrastructural and other associated facilities for their implementation.

True, developing countries do not have adequate funds; they suffer from lack of latest technology and know-how to use modern machinery, yet they cannot afford to sit idle and postpone such an important economic activity. They are, however, faced with a dilemma as, on one side, they want to plan the construction of most modern and all-wheather roads which are lasting as well as ensure maximum social benefits and, on the other, they have to depend on labour-intensive methods in almost every economic development activity mainly to ensure maximum employment opportunities to a large number of people who otherwise remain without a job. When confronted with such a situation, the concerned Governments look around and consider ways and means to launch the road construction programme in such a way as would enable them to adopt a

*Director, Small Industries Development Organisation, New Delhi.

technology which is in keeping with the available resources, the level of human skills and above all with, how far it is possible for them to manufacture/import the proper machinery and equipment. It is in this context that the International Labour Office, Geneva, has brought out a Manual on the Planning of Labour-Intensive Road Construction mainly for the use of those who are engaged in the planning, evaluation and design of road construction projects. These are the persons who are generally responsible for coordinating and implementing road construction programmes in their respective countries. The Manual is divided into two parts—(i) the options and, (ii) the institutional setting.

Part I highlights road planning, road design, methodology of production, the range of labour-intensive technique available, the road construction cost, maintenance cost, users' cost and indirect benefits available to the users, evaluation of alternative technologies both at the market price and the shadow price and lastly the incidence and impact of taxes, foreign loans and grants on the overall road development programme. Part II of the manual deals with the policy choices both physical and financial and the organisational and management strategies to be adopted and lastly the conditions for the tenderers and contractors.

It must be said at the outset that the manual is a treatise dealing with all important aspects of road planning and construction programme. It highlights the considerations which are before the planners and the administrators while taking a decision with regard to construction of a road, the technical ingredients required to make it purposeful, the cost involved, benefits available to the users and above all the financial and technical capacity of a country. A logical treatment has been given to every aspect as mentioned earlier so that the planners and the administrators have full benefit of the choices open to them. Depending on the national priority to a particular road construction programme as also the technical and financial resources available for the purpose, they can take rational view of the situation. No doubt, this is very necessary as otherwise all drawbacks emerging from an unplanned development programme and that too of road construction would follow and lead to economic waste, social disquiet and ultimate loss to the national economy. However, how many of the planners and administrators in developing countries, for whose benefit the manual is claimed to be very essential, are equipped with necessary faculties to examine and evaluate these norms, is a debatable issue. Likewise in democracy

where the economic planning is many a time influenced by the political considerations, it becomes difficult to adopt and follow the ethics of road construction programme as brought out in this book. Nevertheless this does not minimise the usefulness of the suggestions made in the manual which are not only logical but also are backed by the statistical and economic arguments.

One of the objectives before the ILO in bringing out this manual is to afford an opportunity to the developing countries, which are normally faced with the problem of lack of modern technical knowhow as also modern and sophisticated machinery and equipment, to decide on appropriate level of technology which they should follow in their road construction programme. Mr. E. F. Schumacher, the author of the term "intermediates technology" had thought that 'Small is Beautiful'. He was, of course, guided by the maxim that in developing countries where scarcity of material resources, slow development and consequential adoption of most sophisticated technology, the alternative left is to devise and adopt intermediate technology in all spheres of economic activities. In doing so an ideal combination of the resources available, their optimum allocation to various sectors of economy has to be worked out and adopted. Of course, this has to be coupled with the most judicious management of the whole exercise. Certain operations in the road construction activity in a developing country, for example, need better be done by adopting labour-intensive methods. This is particularly true in earth work, which involves a lot of excavation and loading. Even as it is, so far no small manually operated machines appear to have been developed for excavation and loading. Tools used in these operations are basic farm implements such as picks, hoes, shovels and spades. However, these methods are competitive only if the height to be covered is small. Likewise for rock excavative and crushing may also be done within reasonable levels of efficiency by improving the working management at both the input and output stage. The manual has in this regard spelt out the range of labour-intensive technique which could assist the road construction management authority to make a judicious choice of various operations to be done by labour-intensive technique and identify others for which use of machinery may be essential.

Authors of the manual have, in this connection, dwelt on the analysis and interpretation of the data already available with the ILO and other

organisations. This is supplemented with the construction cost as have been modelled in the relevant chapter followed by information on ingredient of maintenance user cost and the resulting benefits both direct and indirect from these costs. All this undoubtedly enhances the usefulness of the manual and to that extent it is expected that administrators, planners and the contractors concerned with the road construction programme will derive maximum benefit from the manual. However, there are limitations with each developing country. These may be of the resources, technology and skills and above all the *inter-se* priority given to road construction programme. Accordingly they will have to devise and adopt the ideal method to accomplish the task which may be assigned to them in this regard. The manual will undoubtedly be of great help to them in arriving at such an ideal combination. In practice, however, guidelines given in the manual will have to be followed with necessary adjustments depending on the overall objective of the programme as also the resources provided for implementing the programme. □

Public Finance in Ancient India

K. R. Sarkar

Abhinav Publishers, 1978, pp. xiii+271, Rs. 60.00

Reviewed by V. S. Mahajan*

How does the system of public finance in ancient India compare with modern concepts of public finance? The author of the book under review addresses himself to this basic issue. He points out that the system that prevailed in the country in the period lost in history compared favourably with modern fiscal and financial system. For instance, the use of currency was widely practised. In other words, a monetised economy was quite popular. There also existed markets where purchase and sale of goods was carried out and secret transactions were discouraged. Strikingly, the traces of modern price

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[illegible] accordance with their tax paying capacity. Also inventory of all possible details of individual, household, like nature of property owned and income derived was prepared. Care was taken in preparing final statements of accounts which were regularly audited.

Thus one finds that the system of taxation, collection of revenue from different sources, the mode of taxation, the mode of disbursement of such revenue over different heads of expenditure and financial administration—as practised in ancient India had a good deal of similarity with the modern mode of taxation and fiscal administration

The author has successfully undertaken the difficult job of spelling out and supporting from ancient texts particularly from Manu's Arthashastra and other sources, the system of public finance as practised in ancient India and by making comparison with the present system of public finance he has proved that the ancient Indian system was improvement in certain respects over the modern system of public finance. This book would be found useful by researchers and students of public finance and economic historians. □

Books Received

Personnel Investment Planning by N. J. Yasaswy Published by Management Education Services, Ravindra Nagar, Hyderabad, March 1978, pp. 304, Rs. 40.00.

mechanism are also to be found in ancient India where prices of commodities were determined through the interaction of demand and supply forces. For borrowing money for financing trade and business there existed individual bankers and also guild banks (forerunners to modern commercial banks). The usual rate of interest charged on such borrowings was 15 percent per annum—a figure very near to the existing commercial rate of interest. Land revenue and custom duties were the major sources of the state income—this shows that trade constituted an important part of India's ancient economy. And interestingly, such pattern of government revenue continued to dominate this country right up to 1950.

The criterion of taxation was the potential paying capacity of tax-payer, rather than actual possession of wealth and income—as is the practice of taxation in modern times. In this way, the author is justified in asserting that the traditional system of taxation in India was an improvement over the modern system. Land which yielded the maximum revenue was surveyed regularly and details like its area, quality, ownership, boundary, etc., were all recorded. This helped updating the land records and introduced an element of equity in land taxation which was based on its productive capacity. The State enjoyed monopoly over salt, wine, mineral and forest products and also operated workshops for the processing of these products.

The state also derived considerable revenue from the sale of these products. During emergencies, the rates of taxation were enhanced. But at the same time care was taken that additional taxes were levied with great foresight. These who contributed their services during this period were exempt from additional taxes.

The revenue thus collected was utilised productively. Besides meeting the expenditure of civil and military administration, the State

New Books : Annotated List*

Ideology of Work

Anthony, P. D.

London, Tavistock, 1978, pp. 340, £ 2.40

The book examines the way in which attitudes to work have been intensified in order to keep pace with the process of industrialisation. Its author argues that two views have subsequently developed : an official view, representing the basis of the employers' injunction that work should be well done, and a radical view that work should be re-organised. He develops his argument to suggest that the official and the radical views have more in common than is often assumed.

Industrialisation, Employment and Income Distribution : A Case Study of Hongkong

H sia, Ronald and Chau, Laurence

London, Croom Helm, 1978, pp. 205, £ 8.95

This is a study prepared for the International Labour Office within the framework of the Research Programme on Income Distribution and Employment of the World Employment Programme. It assesses the impact of Hong Kong's industrialisation and employment growth on its income distribution. Through an analysis of the changes in industrial and occupational structures, employment status, household size, labour participation rate, inflow of labour and wage and employment structures, it considers not only how income distribution alters with economic development, but also the mechanism that has brought about these changes.

*Prepared by S.N. Vig, Documentation and Information Officer, National Productivity Council, New Delhi

Jargon of the Professions

Hudson, Kennelte

London, Macmillan, 1978, pp. 146, £ 7.95

In this book, the author is concerned with what he calls the Professions, the Near-Professions and the Would-Be-Professions. 'Technical Language', he points out, is not in itself a jargon, and it is not in itself a moral or criminal offence to write or speak in a way that is not immediately understood by the man on the street. Every profession necessarily has its own terminology, but much supposedly technical language is bogus, existing only to impress the innocent and unwary. The author provides a useful league table of the worst offenders, and concludes that jargon is the natural weapon of highly paid people with nothing to say and everything to lose.

Managerial Dynamics : A Multi-Dimensional View

Sethi, Narendra

New Delhi, Sterling Publishers, pp. 272, Rs. 70.00

The book cuts across a number of important concepts of general administrative utility blended through a case-oriented workshop approach. The cases are provided with a view towards their domestic and international utility in the global business environment. The book would prove useful for aspiring executives interested in getting an appreciation of the universal compass of managerial theory.

New Dimensions of Cooperative Management

Kamat, GS

Bombay, Himalaya Publishing House, 1978, pp. 503, Rs. 45.00

This book examines the factors which have contributed to a some what chaotic situation in the cooperative sector. It underscores the importance of professionalised management techniques if the cooperative movement is to redeem the promise of the high performance expected of it. It

comments constructively on the role of the state in the growth and effectiveness of the cooperatives and the instabilities from which they have suffered because of the variations in the policies of state governments. It also examines and analyses the importance of management techniques in the cooperative sector in such aspects of business as consumer activity, credit and banking, marketing and processing, and their relevance to Indian situation.

Organisation Development in Public Administration, Part I: Organisation Properties and Public Sector Features

Golembiewski, Robert I and Eddy, William B. Eds.

New York, Marcel Dekker, 1978, pp. 268, $ 9.75

This book brings together important papers dealing with organisation development as applied specifically to public agencies. It considers a number of ethical and value issues associated with OD applications, introduces some basic empirical processes and dynamics that explains why OD works, and provides guidelines and perspective on whether to use OD in public agencies.

Project Formulation in Developing Countries

Mattoo, PK

Delhi, Macmillan Co. of India, 1978, pp. 268, Rs. 70.00

This book deals with all aspects of project formulation—from the stage of identification of the project idea till the stage of final presentations, in the form of a fully documented and data based report. The techniques discussed in this book include system analysis, operations research, techno-economic analysis, PERT/CPM, input analysis, financial analysis and social cost-benefit analysis.

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