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Models of Productivity Measurement

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This paper presents an overview of the models representing major concepts and approaches from authoritative literature. Each of the models surveyed has certain presumptions and a background for its expression. These presumptions have been examined and a critical examination made of their short-comings as well as inadequacies against requirements of a desirable productivity measurement model.

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Introduction

An improvement in productivity is considered vital to achieve several corporate objectives. Measurement of productivity therefore, provides an important tool and a yardstick. It helps to identify areas for corrective actions towards planning, redeployment of resources and other management controls to achieve betterment of performance. It provides measures for comparisons between the performance and the non-performance; between the performance in one period to performance in another or between organisations or plants of an organisation.

Productivity in its highly simplified form and in conventional terms is considered as a ratio of outputs to inputs responsible for the output. In application, however, there are complications in interpreting inputs, outputs, their measures, conversions to common units etc. Productivity in its broader sense carries a different conceptual meaning when it represents performance of a system against the desired performance objectives. Depending upon the concepts considered, a number of models to measure productivity have been contributed by several authors.

Each of the models surveyed in this paper has certain presumptions and a background for its expression. These presumptions have been examined and a critical examination made of their short-comings as well as inadequacies against requirements of a desirable productivity measurement model.

Productivity models are available to measure productivity at micro-levels, say of a workman, a small section or of a department. At macro-level, models have been proposed for a plant, or an organisation, a multi-unit corporation or Industry.

This paper, however, has concerned itself with problems of measurement of productivity at company level/plant level and, therefore, only relevent models have been reviewed.

The survey presented is not, however, the first of its type. Teague and Eilon[1] published a similar survey back in 1973. Another review was published by Mammone[2] in 1980. Since then, of course, the conventional concepts of productivity have been challenged by many authors and a large number of models contributed each projecting a new methodology. This brief survey intends to present an updated status of major concepts propounded with a critical analysis so as to establish the need and directions for future work.

Productivity Measurement Models

The following major categorization is possible on the basis of approaches or concepts on which they have been constructed.

(a) Production Function Models
(b) Financial Ratios as Measures of Productivity
(c) Production Based Models
(d) Product Oriented Models
(e) Surrogate Models
(f) Economic Utility Models
(g) Systems Approach Based Models

Production Function Models

This approach represents one of the earliest attempts to measure productivity. Principally propagated by the economists, the models consider production as the major activity of an organisation and, therefore, infer that measurement of productivity is synonymous to measurement of productivity of the production function.

Production function, in general is preceived to be a function of several input factors. The relationship between the output and the input factors is expressed mathematically through extensive use of economic theory. Several relationship expressions have been proposed.

Cobb-Douglas Function is the classic one and expresses the function as,

$$Q = a L^d K^f e^u,$$

where—

Q = Output
L = Labour
K = Capital
u = Random measurement error
a, d, f are constants.

This field has attracted the attention of a large number of economists and a voluminous econometric work has been reported. This, in itself, has become a specialised subject of study that it is not within the scope of this paper to cover even the major contributions. The bibliography would run into hundreds. Some of the important contributions include the linear theory as expounded by Dorfman, Samuelson and Solow; Kaldor's Technical Progress Function, Arrow's "Learning by Doing" and production function; the Elasticity of substitution as contributed by Arrow-Chenery-Minhas-Solow and extended by U−zawa, McFadden; Chenery's Engineering Production Function, Fellner's Theory of Induced Innovations, etc. Solow[3] has presented a short but comprehensive survey of developments in the Theory of Production, covering econometric work. For the purposes of this article it may be emphasized that the work on the theory of production basically is to find inter-relationship between the inputs of Labour, Capital, technical change etc. so as to give a mathe-

1. Teague J. and Eilon S. "Productivity Measurement : A brief Survey" Applied Economics, S, 1973.
2. Mammone, James L. "Productivity Measurement : a conceptual overview" Management Accounting, June, 1983.
3. Solow, Robert M. "Some Recent Development in the Theory of Production". The Theory & Emperical Analysis of Production, National Bureau of Economic Research, New York, 1967.

matical shape to the production function on an assumption that production is a function of some of the parameters. Its use to determine productivity is indirect and incidental.

Following similar concepts that manufacturing constitutes the major and bulk of a company' s operation and therefore, productivity of a production function would as well represent productivity of the company, Harry Ernst[4] also proposed a model considering output to be a function of inputs, as,

$$\text{Output} = f(X_1, X_2, X_3 \ldots\ldots X_n)$$

where—

$X_1, X_2, X_3. X_4, \ldots\ldots$are the inputs.

In one of the extensive studies conducted, the author identified Technological change and Labour to be the key input factors, so that,

$$\text{Total Output} = C + \Sigma K_i X_i$$

where—

C = a Constant
X_i = Input factor i
K_i = Parameter of X_i

Through regression analysis, in one case, the author found out the relationship,

$$\text{Output} = -30 + 0.70\ \text{MH} + 0.60\ \text{KWH}$$

where—

MH (Manhours) represented the element of labour and KWH (Kilowatt Hours) represent the technological progress of the plant, expressed in the kw capacity of machines and equipment installed.

Financial Ratios as Measures of Productivity

The concept underlying the use of the financial ratios is to assess the financial performance of a company. It is recommended by the contributors that the performance of a company is essentially determined in terms of its growth in total capital employed, in fixed assets, in sales and in profits. The protogonists of this methodology believe that the performance of a company can be studied in areas, such as, Stability, Liquidity, the Assets, Stock and Creditors turnover, Profitability and Coverage.

Stability is recommeded to be assessed through ratio of Net Fixed Assets to Net Worth as well as bebt equity ratio. Performance on Liquidity is assessed through ratios of—

(a) current ratio (current assets to current liability)
(b) quick ratio (current assets minus inventory to current liability)

The Turn-over ratios comprise of—

(a) Stock Turnover (cost of sales to average stock),
(b) debtors turnover ratio (debtors × 365 annual sales),
(c) Creditors turnover ratio (credits × 365 annual purchase).

Profitability ratios are mainly the

(a) gross return on sales
(b) net profits to sales
(c) gross return on total capital employed.

Ratios of Gross Profit to interest and PAT (Profit After Tax) to dividend project Coverage, that is how many times interest charges and dividends stand covered.

Alongside, many cost accountants also have recommended usage of ratios such as—value added per employee, ratios of material consumption to Turnover, energy consumption to Turnover etc.

Production Based Models

These differ from the concepts of 'Production Function'. In the latter emphasis is to arrive at a mathematical expression which describes relationship between the several inputs comprising the production function. Under the approach of Production Based Models, production of goods/services is perceived as

4. Ernst, Harry "Accounting for Productivity Changes" Harward Business Review, May-June 1956.

the only output. Productivity is considered as a ratio of output (i.e. goods manufactured or services rendered) to Inputs.

Production Based Models can be categorised into two variations depending upon the way the valuation of output (production) is carried out.

(i) Output as value of production

(ii) Output as value addition.

Models based on output as Value of Production

Ruist[5] proposed measurement of output (Production), as :

$$\text{Production Index} = \frac{\text{Production of Period}}{\text{Production of Base Period}}$$

$$= \frac{\sum_j q_j^1 \times \frac{hj^o}{qj^o}}{\sum_j q_j^0 \times \frac{hj^o}{qj^o}}$$

where q_j = Production of Product j

hj = Total Number of manhours in Production of Product j

o – refers to base period.

Tsujimura[6] also considered productivity essentially "the quantity of production by a quantity of labour or the output per unit of labour input" and accordingly suggested measurement of productivity as :

Physical Productivity = Q/L

where – Q = Quantity Produced

L = Labour

Labour is the sum total of real work hours of workmen and exclude hours of belated attendance, rest hours etc. Tsujimura also suggested measurement of value productivity as equalling :

$$\frac{\text{Value created}}{\text{Labour Input}}$$

Kendrick and Creamer[7] are considered to be the founders of this concept and take the credit of presenting the first model for measuring productivity in a systematic manner.

The authors consider that a Company's Productivity can be measured and analysed in basically three types of productivity indices :

(a) Total Productivity Index :

$$= \frac{\text{Total Output}}{\text{All Input factors}}$$

(b) Total factor Productivity Index :

$$= \frac{\text{Net Output}}{\text{Total factor Input}}$$

where – Net Output = Output – Intermediate goods and services

Total Factor

Input = Manpower Input + Capital Input

(c) Partial Productivity Index :

$$\frac{\text{Output}}{\text{One factor of Input}}$$

Input factors are considered as Labour, Capital and Materials and the Partial Productivity Index, so obtained are referred to as Partial Productivity of Labour, Partial Productivity of Capital and Partial Productivity of Materials.

This model of productivity measurement as suggested by Kendrick and Creamer has influenced researchers extensively and a large number of models have been formulated which are either modifications or extensions of the suggested approach. Faraday[8] who has contributed a great deal to propagate the concept of productivity and need of its measurement, has also taken the same concept of relationship index of output to input and has suggested :

TPM (Total Productivity Measure)

$$= \frac{V}{M + Q + C}$$

5. Ruist Erik, "Production Efficiency of the Industrial Firm" Productivity Measurement Review, Dec. 1961.
6. Tsujimura Kotaro, "The Measurement of Productivity" Asian Productivity Organisation, Tokyo, 1963.
7. Kendrick John W and Creamer Daniel, "Measuring Company Productivity : Handbook with Case studies" The Conference Board, New York, 1965.
8. Faraday, JE "The Management of Productivity" Management Publication Ltd., London, 1971.

where—

V = Value of the total output
M = Input of Manpower
Q = Input of Materials
C = Input of Capital

Ramsay[9] has proposed basically an extension over Faraday's model and has suggested measurement of Productivity as Overall Productivity Measures,

$(OPM)_1$, $(OPM)_2$ and $OPM)_3$, so that

$$(OPM))_1 = \frac{C + P + M}{C - M}$$

where—

C = Total Cost
P = Profit
M = Materials Cost

All the data are supposed to be obtainable from the Company's annual books of accounts.

Leon Greenberg[10] has also recommended the use of Kendrick-Creamer model and has provided interpretation and definition of outputs and inputs which are easily understandable to facilitate usage, without the use of technical jargons. Craig and Harris[11] have provided another major contribution in proposing a model for productivity measurement. Although their approach is essentially on the lines of Kendrick and Creamer, these authors have not favoured the measurement of partial productivity measures and have in turn proposed, total productivity measure :

$$Pt = \frac{Ot}{L+C+R+Q}$$

Where—

Pt = Total Productivity
L = Labour Input factor
C = Capital Input factor
R = Raw-materials and Purchased parts Input factor
Q = Other miscellaneous goods and services Input factor
Ot = Total Output

The authors have emphasized on units 'Produced' rather than Units 'Sold'.

The authors differ from Kendrick-Creamer approach also to the extent that value concept of output and input measures has been used as against physical measures as adopted by Kendrick-Creamer.

Following the same basic approach of productivity as a ratio of output to Inputs, Mundel[12] also emphasizes the need of productivity measurement for productivity improvement and recommends, productivity index (PI) to be arrived at as :

$$PI = \frac{OMP/IMP}{OBP/IBP} \times 100$$

where—

OBP = Aggregated Outputs, Base period
OMP = Aggregated Outputs, measured period
IBP = Inputs base period
IMP = Inputs measured period.

The numerator in the above model refers to current performance index and the denominator to the Base Performance Index. Productivity Evaluation Centre (PEC) Virginia Polytechnic Institute and State University[13] has also contributed a model to measure Company productivity.

As per this model, TPF Productivity Index can be measured as,

$$Pt = \frac{Output}{Input}$$

9. Ramsay, MR. "Overall Productivity Measurement" Conference Papers, World Congress on Productivity Science Bombay—Dec. 1973.
10. Greenberg, Leon "A Practical Guide to Productivity Measurement" The Bureau of National Affairs, Inc. Washington DC 1973.
11. Craig Charles E and Harris Clark R, "Total Productivity Measurement of the Firm Level" Sloan Management Review, Spring 1973.
12. Mundel, Marvin E, "Measures of Productivity" Industrial Engineering, May 1976.
13. Ghare P.M., "Models for Total Productivity Measurement at the Corporate Level"—1982. Production Evaluation Centre at Virginia Polytechnic Institute and State University—1982.

where—

Output = Sales+Potential Sales and again,

Sales = Net Sales

$$\text{Potential Sales} = \text{Change in Inventory} \times \frac{\text{Sales}}{\text{Costs}}$$

Change in Inventory = Inventory of Current Period minus Inventory of Last period

Costs = Cost of Goods sold

And, Input = Costs+Implied Costs of Capital

= Costs+Depreciation+Opportunity Cost on Invested Capital.

= Costs+Depreciation+(Inflation rate+3%)×(Net equity+Debt)

Invested Capital has been defined as comprising of net share-holders equity and long term debts.

The model presumes that opportunity cost interest rate is 3% more than the prevalent inflation rate.

Models Based on Output as Value Addition

The protogonists of this concept believe that there is no contribution from production function to the cost of materials and other parts purchased and as such only the value addition is the true output.

Faraday introduced value added concept in measuring productivity so that—

$$\text{Productivity} = \frac{V-Q}{M}$$

$$\text{and also} = \frac{V-Q}{M+C} \text{ and}$$

$$\text{Total Productivity Measure} = \frac{C+P}{C}$$

where—

P = Profits

Ramsay also has proposed value addition models,

$$(OPM)_2 = \frac{C+P+M}{C}$$

$$(OPM)_3 = \frac{C+P}{C-M}$$

The best known model on value addition is contributed by Taylor & Davis[14] who have proposed—

Total Factor Productivity (TFP) as an index of productivity to be arrived at as :

$$TFP = \frac{(S+C+MP)-E}{(W+B) + [(Kw+Kf) \cdot fb \cdot df]}$$

where—

S = Sales

C = Inventory

MP = Manufacturing Plant

E = Exclusions

W = Wages & Salaries

B = Benefits

Kw = Working Capital

Kf = Fixed Capital

fb = Investor Contribution adjustment

df = Price deflater factor

S, Sales represents the sales billed deflated to a base year.

c, the inventory change is the difference between the closing and the opening inventories of all the three types i.e. raw-materials, work-in-progess and the finished inventory all deflated to the base year.

MP – Manufacturing plant covers maintenance, repairs, manufactured items for R & D etc all produced within the plant;

E = the exclusions represent items purchased (supplies, components etc) which do not result from production efforts.

14. Taylor BW and Davis K R, "Corporate Productivity—Getting it All together" Industrial Engineering, March—1977.

Factor fb represents capital after depreciation for each year weighted by the rate of return in the base year.

Taylor-Davis Model forms a major milestone in proposing methods of productivity measurement. It provides a detailed methodology of what to include or exclude from outputs and inputs and suggests as to how to deflate working and fixed capital to base values.

Product-Oriented Models

The underlying philosophy of this concept is that there is the necessity of measuring total earnings of each of the products. Bahiri and Martin[15] advocate construction of the product Productivity Index which is given "by the total earnings of the product over the cost of producing that product". It is also suggested that the products can be ranked vide this index so as to identify areas of improvement and other corrective steps.

A similar "productivity through product costing approach" is suggested by Horngren[16], who suggests two measures—

(a) rate of return on investment and

(b) transfer price

If the transfer price being charged by department producing (say, Production Department) meets the competition in market at expected levels of profitability, obviously, coupled with the rate of return measure, the operation is productivity oriented. For apparent reasons the measure of transfer price can be made applicable to finished goods only for sale in the market.

Smith[17] proposed Omni factor Model which considered output as a summation of all products in terms of their marginal costs.

Inputs under the O nni factor model are measured in terms of total cost of input as—

(i) Raw material Costs

(ii) Personnel Costs

(iii) Capital costs (covering interest on capital, depreciation, stock investments etc).

(iv) Indirect Production Costs, and

(v) Purchase for Production (utilities etc).

Output, under this model is in terms of marginal cost of all the weighted sum of all products considered as outputs.

If, A, B, C, —, —, are the products, then :

$$\text{Aggregate Output} = \text{Output A} + \left(\text{Output B} \times \frac{\text{AMC of B}}{\text{AMC of A}}\right) + \text{Output A} + \left(\text{Output of C} \times \frac{\text{AMC of C}}{\text{AMC of A}}\right) \text{ etc. etc. where}$$

$$\text{AMC} = \text{Average Marginal Cost}$$

$$\text{AMC of A} = \frac{\text{Total Input Cost of A}}{\text{Physical Output of A}} \times \frac{100}{1}$$

$$\text{Productivity} = \frac{\text{Aggregate Output}}{\text{Inputs}}$$

Productivity Index can be calculated with reference to Standard Productivity as 100, as

$$= \frac{\text{Subsequent Productivity Level}}{\text{Standard Productivity Level}} \times 100$$

Sumanth's[16] Total Productivity Model, a result of his Doctoral dissertation, is a product oriented model which provides for arriving at total productivity indices of each product as, finished units produced, partial units produced, dividends from securities, interest from bonds, and other income. Similarly, Inputs in

15. Bahiri S and Martin, HW, "Productivity Costing and Management" Managemcnt International Review Vol. 10, No. 1, 1970.

16. Horngren, C.T. "Accounting for Management Control : an Introduction" Prentice-Hall, Englewood Cliffs, NJ. 1965.

17. Smith, Ian G. "The Measurement of Productivity" Gower Press, 1973.

16. Sumanth David J. "Productivity Measurement in Manufacturing Companies by using a Product-Oriented Total Productivity Model" Proceedings, spring Industrial Engineering Conference, 1980.

context shall be "the ratio of performances towards organisational objectives to the totality of input parameters".

Stewart suggests selection of 'Key activities' as

Sumer Aggarwal's model[22] Composite Productivity Measure is again a type of surrogate model, where the

21. Stewart W.T. "A Yardstick for Measuring Productivity" Industrial Engineering, February, 1978.

22. Aggarwal Sumer C. "A Study of Productivity Measures for Improving Benefit"—Cost Ratios of Operating Organisation" Int. J. Prod. Res. Vol. 18, No. 1, 1980.

Sumanth's model have been considered to be comprising of labour, capital, material, energy and other expenses. Only tangible inputs and outputs are considered.

As per this model, Total Productivity of a Firm (TPF) is given by,

recommend that labour productivity can be arrived at as under :

$$P_i^B = \frac{\Sigma_j V_{ij} B^* Q_j B}{\Sigma_j V_{ij} B^* Q_j B}$$

where—

P_i^B = Productivity of input factor 'i' at period B

objectives of Employee satisfaction, customer satisfaction etc are suggested to be measured through surrogate measures.

Sumer Aggarwal argues that the essential objectives of any company engaged in manufacturing and marketing the products are the following :

(i) Investor satisfaction.

(ii) Employees satisfaction.

(iii) Customers satisfaction.

(iv) Suppliers satisfaction.

The author, therefore, recommends that each of this should be measured and proposes indices as under:

$$\text{Investor Satisfaction} = \frac{\text{Net Profit}}{\text{Total Investment}}$$

$$\text{Employees Satisfaction} = \frac{\text{Total Value added}}{\text{Total No. of wage man-hours}}$$

$$\text{Customers Satisfaction} = \frac{\text{Total Sales Revenue}}{\text{Total No. of customers}}$$

$$\text{Suppliers Satisfaction} = \frac{\text{Total purchases (Monetary)}}{\text{Total No. of Suppliers}}$$

On the same principles, the author recommends composite productivity index=

A × Investors satisfaction +

B × Employees Satisfaction +

C × Customers Satisfaction +

D × Suppliers Satisfaction.

A, B, C & D are the co-efficients which represent the weightage common objectives have to each of the five satisfaction parameters. The author also recommends that the same can be obtained through regression analysis using the company's past historical data.

Economic Utility Models

Several authors have recently veered to a point of view that productivity is essentially related to the economic activity of an organisation. Productivity unrelated to utility has no significance. Economic activity as well as utility function in an organisation can be in several directions. This can be directed to achieve maximised profit; it could be achievement of growth in output, or it might be towards attainment of one or several of the performance objectives. Productivity measurement models under this approach do not follow the conventional ratio concept of output to input and recommend use of multiratios, each ratio reflecting on a particular economic activity or utility function.

Kurosawa[23] in his well reasoned paper considers that performance of economic activity comprises of—

(i) profitability, measured as the ratio of profit to capital

(ii) Rentability, as ratio of total revenue to total cost.

Both of these, Kurosawa argues, are affected by Productivity effect, comprising of Technical Change and production scale as well as Market effect comprising of Price of Products and Price of Input factors. Kurosawa considers production function as linear in which "gross output is directly proportional to the total input" and productivity as a "Proportional constant that converts total input into gross output and any change in the proportional constant is defined as technical progress". Kurosawa proposes measurement of Index of rentability as, = (Index of Market Effect) × (Index of Productivity)

where—

Index of Market Effect

$$= \frac{\text{Index of Price of products}}{\text{Index of Price of Input factors}}$$

& Index of productivity

$$= \frac{\text{Index of Output of Products}}{\text{Index of total input factors}}$$

Various Indices as referred above are arrived at as,

I_p, Index of Price of Products

$$= \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}$$

I_p, Index of Price of Input Factors

$$= \frac{\Sigma P_1 Q_1}{\Sigma P_0 Q_1}$$

23. Kurosawa Kazukiyo, "An Aggregate Index for the Analysis of Productivity and Profitability" Omega, Vol. 3, No. 2, 1975.

I_0, Index of Output of Products

$$= \frac{\Sigma P_0 q_1}{\Sigma P_0 q_0}$$

I_1, Index of total Input Factors

$$= \frac{\Sigma P_0 Q_1}{\Sigma P_0 Q_0}$$

where—

P = Price of commodity produced

q = Quantity of commodity produced

P = Price of Input factors

Q = Quantity of Input factors

Suffix 'O' = pertains to base period

Suffix '1' = pertains to Current Period.

Kurosawa argues that with the help of this approach, the effect of technical Progress and the effect of scale of production can be identified. In similar context market effect through price of products and price of input factors can also be identified in productivity.

American Productivity Centre[24] has also suggested a model to measure Company's Productivity. APC Model recommends three principal indices as,

(a) Productivity Index which is the quantity ratio of Outputs and Inputs in Current period to the base period,

(b) Price Recovery Index, which is the price ratio of current period to the base period, and

(c) Cost Effectiveness Index, which is the value ratio of outputs and inputs in current period to the base period.

APC also suggests use of three variances,

(a) Cost Effectiveness Variance, which is the difference between the change in the value of the products and the change in the value of the inputs,

(b) Productivity Variance, has been defined as the differences between the change in the quantity of the product and the change in the price of the input used, and

(c) Pricing Recovery Variance which is the difference between the change in the price of the product and the change in the price of the inputs used.

It would be noticeable that the principal data in APC model pertains to the price and quantity of each of the inputs and outputs in the two different periods. The outputs are essentially the products sold (or manufactured).

NPI[25] approach to productivity measurement follows similar lines. It recommends, productivity as:

$$\text{Productivity} = \frac{\text{Business Results}}{\text{Resource Inputs}}$$

NPI has introduced concept of Economic Productivity (E.P.) as,

$$\text{E.P} = \frac{\text{Sales and Revenue}}{\text{L+C+M\&S}}$$

where—

L = Cost of Labour

C = Capital

M&S = Materials & Services

$$\text{as also, EP} = \frac{\text{Value added} + (\text{M\&S})}{\text{L+C+(M\&S)}}$$

where—

Value added = Sales & Dividends − (M&S) consumed. Mali[26] considers productivity essentially a combination of effectiveness and efficiency so that,

$$\text{Productivity Index} = \frac{\text{Effectiveness}}{\text{Efficiency}}$$

The author defines effectiveness as related to performance and efficiency as related to resource utilisation. In other words, Mali's approach is to measure performance and resource use. In this context

24. American Productivity Center Inc. "Productivity Measurement : An Executive Overview", 1978.

25. Norwegian Productivity Institute, "Creating Value and Measuring Productivity"—1979.

26. Mali, Paul "Improving Total Productivity" John Willy and Sons, 1978.

Mali's approach is significantly different from the other conventional approaches. The author considers productivity as a synergistic process where" a change in one part of the process may set up a source of reverbarations through out the process".

Output can be quantitative and qualitative. Therefore, measure of productivity requires combination of qualitative assessment and quantitative assessment. The author in this context recommends measurement of productivity through five categories of ratios:

(i) Overall Index $= \frac{\text{Overall Output}}{\text{Overall Input}}$

This represents financial outputs as related to total resource inputs of the entire company.

(ii) Objective Ratios $= \frac{\text{Actual Result}}{\text{Expected Results}}$

This provides a reflection of achievement as related to objectives planned at the beginning of the period of schedules.

(iii) Cost Ratio = Performance over cost. This represents performance with reference to costs.

(iv) Time standard ratio : Performance over time. This measures performance with reference to time schedule.

(v) Work standard ratio = Work output over resource standard. Through this ratio, work units are related to normal standard practice in the organisation.

Besides, Mali also recommends use of EPM (Evaluated Productivity Measure) as,

$$\frac{\text{Objective effectiveness}}{\text{Efficiency}}$$

This concept has been drawn from MBO Approach. In similar context, the author also recommends measurement of productivity through check-list indicators as

$$PI = \frac{\text{Checklist indicator completed}}{\text{Total indicators}}$$

Furthermore, Productivity is also recommended to be measured by using productivity audits. This concept is administered by listing down the items requiring audits and assigning weightage factors to the same.

Eilon, Gold and Soesan[27] have laid more emphasis on measurement of productivity growth which has been defined as ratio of growth of output to the growth of input between the two periods. Growth of output is the ratio of outputs evaluated as aggregated product of physical quantity and price over the two periods. For changes in price between the two periods, an arithmatic or geometric mean price is recommended. A similar evaluation methodology is applicable to the input growth. Gold[28] has proposed "Productivity-Cost-Profitability (P−C−P) system which integrates,

(1) the network of productivity relationship,

(2) the structure of cost relationship, and

(3) managerial control ratios.

The author emphasises that "a change in any component, such as output per manhour, may be merely the passive resultant of changes initiated elsewhere in the network". As such it is necessary to identify the source of impact. Similarly, the analysis on productivity must also include the economic effects projected through "the structure of cost relationships". The "managerial control ratios" suggest and trace causes for variations in profitability.

Systems Approach Based Models

As an approach entirely different from the conventional Productivity measurement models, Mason[29] considers productivity as a systems concept. Mason advocates that the exercise of productivity measurement is basically reduced to measure the "Level of

27. Eilon Samuel, Gold Bela and Soesan Judith "Applied Productivity Analysis for Industry" Pergamon Press, Oxford, 1976.
28. Gold Bela, "Productivity Analysis for Management" IIE Transactions December, 1982.
29. Mason, Richard O. "A General Systems Theory of Productivity" International Journal of General Systems, Vol. 5, No. 1, 1978.

output a system has generated in relation to the input resources consumed during the production process". The author further recommends that the measurement of productivity shall depend upon the type of environment of the system.

Drawing upon the theory of systems environment as advocated by Emery & Trist, Mason has detailed out concepts of productivity measurement with each of the four types of environments. For placid, randomised environment, the author recommends productivity as a measure of conversion of inputs to outputs. The author terms it as process of flow productivity. In case of Placid, clustered environment, the author refers the productivity measure as bounded productivity which can be both measured for outputs as well inputs. For example, bounded output productivity is the ratio of actual output to maximum output. For the third type of environment that is disturbed and reactive, the author refers the productivity as systemic productivity equalling.

$$\frac{\text{Actual output}}{\text{Maximal output}}$$

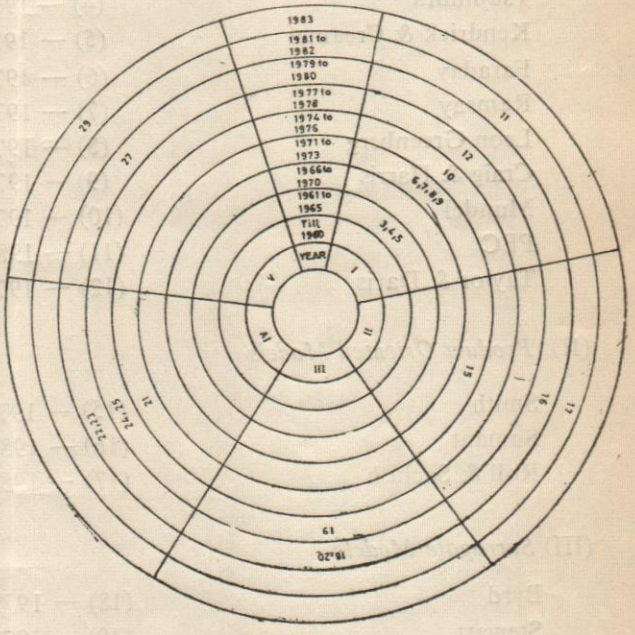
that could be produced by any feasible system of the same class. For the fourth type of environment of turbulant field, the author has not suggested any measures.

Chronologically speaking

As briefly mentioned earlier, the subject of productivity, its concept, its advantages and its imperative need to improve upon the performance has attracted a very wide attention from all concerned, be it the economists, politicians, accountants, industrial engineers, labour leaders etc. An extensive literature exists in the form of books, articles, papers and other briefs. A full bibliography would run into hundreds of titles.

The measurement of productivity is a subject however of relatively recent interest. Initially, the usual financial ratios with a few extensions came to be advocated as the ready reckoners of productivity. These included profits, returns on investment, inventory ratios, debt to equity ratios etc. Some of these financial ratios date back to the very beginning of the industrial era and as such if it is accepted that financial ratios represent the measures of productivity it can also be said that since a long time certain measures of productivity have existed. Financial ratios, however, do not represent the productivity as is understood these days. Financial ratios at best can be understood to project financial performance of a company.

Productivity measurement in real sense is of recent birth. Before tracing the papers of productivity measure ment chronologically, two points need clarification. First, any exercise on productivity measurement must be considered to provide a system, a methodology whereby the data can be used to arrive at tangible, understandable figures, be they in the form of ratios, indices, aggregate numbers or similar other expressions.



Chronological Distribution

Secondly, the productivity measurement model so suggested must be possible to apply to another organisation in similar context within the specified constraints. In other words, the proposed productivity measurement model should not be such as has been solely developed for one particular use, so as to lose its generality for use elsewhere.

With the above understanding, the authors have been able to trace twenty three productivity measurement

models which have been briefly reviewed in preceding paras. It would be seen that the first of the models covered by the authors pertains to 1982-83.

Categorised, the following authors have contributed the models. Only such models have been considered which provide mathematical formulations in the generally accepted interpretation of a model. Again only direct measurement models are considered.

Indirect models, for example production function models are left out.

(I) *Production Based Models*

Ruist	(3) — 1961
Tsujimura	(4) — 1963
Kendrick & Creamer	(5) — 1965
Faraday	(6) — 1971
Ramsay	(7) — 1973
Leon Greenberg	(8) — 1973
Craig & Harris	(9) — 1973
Mundel	(10) — 1976
PEC	(11) — 1982
Taylor & Davis	(12) — 1977

(II) *Product Oriented Models*

Smith	(15) — 1973
Sumant	(16) — 1980
Roll & Sachish	(17) — 1981

(III) *Surrogate Models*

Byrd	(18) — 1979
Stewart	(19) — 1978
Sumer Aggarwal	(20) — 1980

(IV) *Economic Utility*

Kurosawa	(21) — 1975
APC	(22) — 1979
NPI	(23) — 1979
Mali	(24) — 1978
EGS	(25) —1978

(V) *Systems Approach*

Mason	(27) — 1979
Sardana & Prem Vrat	(29) — 1983

Chronologically the models have been contributed as,

Upto 1960	— Nil
1961 to 1965	— 3
1966 to 1970	— Nil
1971 to 1973	— 5
1974 to 1976	— 2
1977 to 1978	— 4
1979 to 1980	— 6
1981 to 1982	— 2
1983	— $\frac{1}{23}$

It would be seen that the period 1973-76 brought out as many as 7 models, all of these propagating production or product based productivity measurement. 1978 onwards, there is a perceptiable change in concepts. The contributions and new models suggested have accepted that productivity of an organisation does not refer to production function alone but includes other outputs as well. Besides, productivity came to be recognised as a multi-factor approach with more and more emphasis to consider an organisation as a system. The period 1977 to 1980 contributed ten models. Debate on measurement of productivity still continues. There is no single model which can meet all the requirements.

A Critical Overview

Each of the models briefly discussed in earlier paras has its merits when seen in the proper perspective. A critical analysis is being made in the following paras not with a view to find faults with the models but with an intention to bring out inadequacies so that a more suitable and appropriate model emerges to measure productivity.

The production function models have assumed that Labour and Capital form the only or major inputs of a production function. In practice other input variables are also present. For example, the scale of production, technology of methods, tools, manufacturing processes, the product mix, the process cycle, the product quality requirements play important roles. These factors of inputs are not expressable in the type of mathematical expressions suggested. Models based

on production function are indirect models of productivity measurement. The underlying concept is to express a particular production function in a relationship of an additive or a multiplicative expression at a time period and use the same to arrive at obtainable production value of a different period with varied data of input factors. The actual production value achieved can then be compared to obtainable value to provide an index of productivity. This approach can have a validity if it is presumed that the production function shall have the same major input factors at both the periods as well as the relationship of the factors of production shall remain unchanged. In practice, however, it is altogether different. Input factors shall vary depending upon the requirements. More important the relationships shall undergo radical changes as the same are dependent on product mix, technological requirements, size of operations etc. For example, requirements of large scale production may need high capital intensive facilities so as to change K (as well as KWH in Harry Ernst model) with reference to L. Similarly, another product mix may make the production function to be highly labour oriented so as to make L as more prominent.

Financial ratios are generally derived from the published books of accounts that is Balance Sheet and the Profit & Loss statements of a company. Principally, these financial statements are meant to serve different objectives that is of providing information about the financial status of the company to share-holders, investors, speculators, public etc. The data contained does not throw light on as to how well all the resources have been utilised. These show as to how well the company has used funds at its disposal and as to how it stands with reference to deployment of capital in its various activities. At best the financial measures can be said to represent the financial performance of a company.

Models based on production or product have a lot of similarities and, therefore, also have common inadequacies. Some of the major inadequacies and inherent fallacies are noted as under:—

(a) *Factorial productivity is not representative*:

Factorial productivity does not project the status of productivity of a company. For example Labour productivity can be greatly altered by adding to the inputs of capital and materials. A highly capital intensive automatic machine or a higher degree of fabrication in raw materials will obviously increase output per labour yielding in higher index of labour productivity. But simultaneously the capital and the materials productivities shall go down. There are trade offs in between all the inputs and a gain for one factorial productivity shall be at the loss of the other.

(b) *Labour productivity has too much emphasis*:

The models surveyed have too much emphasis laid on labour as input. It might be true in an environment where labour would have accounted for, as a scarce and a costly resource as compared to other inputs. In present day working, technology and managerial decision making specifically in areas of deployment of resources play a more important role. Again labour productivity is altered through many methods such as tooling, machine tool selection, industrial engineering practices etc.

'Labour' input as such in its form as detailed in models carries lesser significance.

(c) *Production/products are not the only output*:

The models have presumed that principal activity of a firm is manufacturing of products. This is only partially correct. An organisation has long term as well as short term goals. An organisation, in order to achieve its objectives, also deploys its input resources on activities such as quality improvement, research and development, market development etc. Had these resources been spent exclusively on production currently in hand, obviously this would have yielded a higher production and hence, higher productivity of the conventional concept. Production in the form of goods produced or sold alone cannot be representative of the total output. It is the achievement, against performance objectives which should account for the output.

(d) *Market has an impact on production*:

Market prices vary and fluctuate widely as these are dependent on demand and supply as well as other environmental factors beyond the controls of an organisation. The use of market/selling prices in the valuation of output can, therefore, project distorted 'outputs'. High selling prices, because of the competitors plant being under temporary closure, would boost up the output value even though output in physical units would have remained same (or gone down) thus creating an artificial increase in productivity. The same can be said of profits if these are included in the output. In another context also, marketing has an impact on production. A good demand in market generates pressures on production function to meet the challenge and the production goes up. A slagging demand in the market, on the other hand, also creates a similar dampening spirit in production function so as to bring down the productivity.

(e) *Value addition & Productivity*:

Value addition models are based on vital presumptions that productivity lies in generation of value-addition, The more the value addition, the better is also the control over performance in the market place as the product pricing policy can be varied with reference to internal cost structure. A low value addition on the other hand shows dependence on suppliers and sub-contractors and , therefore, provides lesser control on profitability. It is presumed that the resources are spent on conversion processes and the effectiveness of the conversion processes, is projected in the form of value addition. Value addition is generally the total cost of products produced minus the cost of purchases. A high wage in other words would automatically increase the value of products appearing as numerator and hence increase productivity. Measure of Value-added per manhour becomes a misnomer of productivity.

Surrogate models have limitations as these use substitute parameters. The inter-relation between these parameters as well as their co-relation to the outputs can vary depending upon the environment and actual expectations of the company. The relationship is not static, as a result the results cannot be compared to values of a base period. Even simple requirements such as a change in product mix or change in technology can effect the expression.

A surrogate measure based on 'pay' or wages paid can be used in a highly restricted way at small set ups. A high wage need not reflect a high productivity unless it is a set up which works purely on piece-rate systems. Similarly, a low wage need not reflect poor productivity. Besides monetary compensations, productivity of labour is influenced by many other factors.

Models based on economic activity or utility are the latest additions to the science of productivity. The essential feature of these models is that it is recognised that no single index can represent productivity and multitude of indices or ratios are needed. Further, output is not the goods produced or goods sold only. Output also includes performance in other areas as well. Productivity does not represent the total performance of a company, yet simultaneously productivity also cannot be considered to be entirely isolated so as not to represent performance. The approach, therefore, is to link it with financial performance, costs, management objectives etc and to treat it as a subject of not merely output/input ratio but a subject of multi-ratios or indices. Productivity in this sense acquires a broader meaning.

The main disadvantage of these approaches is that these do not provide one single indicator of productivity as a yard-stick of comparison.

Systems approach is the only logical approach when the measurement of productivity is required to be related to an organisation. Mason has reasoned it out in a logical and objective way. However, the models suggested for each of the environments are based on the conventional methodologies and consider both outputs and inputs in the traditional manner. As a result the same fallacies and adequacies have crept in.

A Fundamental Inadequacy

All the models surveyed have presumed that it is

possible to define and measure productivity in terms of a casual relationship expressed as a ratio between output and input. It has been assumed that the relationships in precise defineable terms not subjected to any changes in the course of convertion activity. The relationship is thus seen to work in well defined limits, specifications and parameters which are set and remain unchanged throughout. As has rightly been argued by Shone,[30] this can happen in only mechanical system. Organisations work differently. An organisation works as a system. It comprises of functional areas which again can be assumed as systems in themselves. These systems influence each other leaving an impact on each others performance. Any system cannot, therefore, claim a performance resulting out of exclusive efforts of its own. An output under the systems approach, therefore, comprises of total performance contributed by the sub-systems interacting with each other.

In a mechanical system, the concept on which the con ventional models are based, inputs are presumed to be static with a fixed known relationship to each other. However, in actual practice, the inputs are dynamic as well as their relationship with each other is ever-changing. For example, labour as input would change in its characteristics, skills, behaviour, co-operation, attitudes, adaptability etc in an organisation dependent on internal as well as external environment. Labour input in its full attributes of skill and behavioural aspects cannot be expressed in terms of wages paid or hours clocked. In similar context, other inputs such materials or capital would have dynamic interaction with other inputs.

Further, as Smith has also pointed out "human element of enterprise permeates production. More importantly human labour is one of the inputs incalculably 'mixed-in' with all the other inputs to make up the system." Labour cannot be perceived as a precise identifiable input responsible on its own for an output. It is subject to controls, deployment and is put to work on different machines with varying technological constraints and asked to carry out jobs with tools, methods all as a result of certain management decisions. In a different context, same could be said of other inputs. Bela Gold[26] also echoes similar views in his well reasoned paper : "It is inherently impossible to measure the physical efficiency of manufacturing processes or other economic activities because the concept is based on a false analogy." Gold points out that conventinal approaches on productivity measurement have presumed that "qualitative characteristics of materials, labour, capital goods or products" remain unchanged. In actual practice there are wide variations and these changes reflect on cause-effect relationship of output and the input. Mason[27] has also strongly recommended to view productivity in a total context and has recommended systems approach for measurement.

However, even though the redundancy and inadequacy of the conventional approaches has been fully recognised by many authors, as referred above, new models of analysis proposed in each case do not measure up to the requirements. Elements of cause-effect theory and incorporation of the traditional inputs viz Labour, Capital, Materials etc. are evident in the new models proposed. Even output has been considered as products/services produced as in conventional models. The concepts of change have not been given shape in a model. An organisation works under the impact and influence of an external environment. This influence can improve the productivity as well as prove detrimental to the productivity of an organisation. In order to understand the true or real productivity, the calculated productivity requires normalising by a factor representing the effect of the external environment. This aspect should be incorporated in the model.

A new Approch is needed

Inadequacies of the conventional models of measurements have been briefly examined in the preceding paras that these do not represent the productivity of an organisation seen as a system. Besides, the known models have built in fallacies. There are also problems of measures, defining and conversion of outputs as well as inputs to common units of measurement and reference to a common base.

A new approach is positively called for which can consider productivity in its wider and proper perspec-

30. Shone, K.J. "Analysis of Controls" Time and Motion Study, 1962.

tive. It will be necessary to examine major requirements of a desirable productivity model so that these get fully reflected in any proposals of improved models.

Requirements of a desirable productivity model

(a) A good measurement model should help management in analysing areas of improvement and in monitoring the performance.

(b) It should take into account all possible outputs in an organisation. Outputs are not necessarily the products manufactured or products sold. Outputs can also mean services generated, infrastructure created, service to the society as well as performance against objectives.

(c) In similar context all possible inputs must be considered. Inputs are the resources responsible for performance.

(d) Productivity is an aggregated function and it must take into account interaction of inputs as well as outputs. An organisation acts as a system. Productivity measurement should project productivity of the system.

(e) External environment plays an important role and affects the performance of an organisation. Productivity measured should therefore be normalised to take into account the effects of external environment so as to obtain a clear idea of the performance of the organisation.

(f) Data which any model proposes to use should be easily available and comprehensible. It should be management oriented and directed.

Performance-Objectives-Productivity (P-O-P) Approach

Drawing strengths from the concepts of Management By Objectives (MBO) as well as systems approach, Sardana & Prem Vrat[31] have proposed P-O-P model of measurement. This approach considers organisation as a system and its traditional functional areas of Production, Finance, Marketing etc. as its sub-systems. P-O-P approach does not recognise 'Out-put' only as products/services produced as is considered in the conventional models. It considers "performance against objectives" as the output of a system (or of a sub-system). Similarly, Labour, Capital, Materials etc. the traditional inputs are not the inputs in P-O-P approach. The inputs are considered as defined and inherent in the performance objectives. The performance objectives are the defined objectives of an organisation to be achieved against planned, identified resources. P-O-P approach also takes into account such of the performances which are not quantified in conventional measures.

As per P-O-P approach, productivity is,

$$PI = \sum_{i=1}^{n} \sum_{j=1}^{m} W_i W_{ji} \frac{O_{jit}}{O^*_{jit}}$$

where,

O_{ji} = performance j at time t of system i

W_{ji} = Weightage factor for performance j of system i

W_i = Weightage factor for system i

m = number of performances (or performance objectives)

n = number of systems

* = refers to performance objectives

subject to,

$$\sum_{j=1}^{m} W_{ji} = 1 \quad \text{and}$$

$$\sum_{i=1}^{n} W_i - 1$$

Conclusions

This paper has presented a survey of the known productivity measurement models to measure productivity at the organisation Level. Only such models have

31. Sardana GD and Prem Vrat. "Performance-Objectives-Productivity (P-O-P): a conceptual framework and a mathematical model for Productivity Measurement" Productivity, Oct.-Dec. 1983.

been chosen which project major concepts. A critical overview has been made and inadequacies as well as fallacies inherent in the models have been brought out. A plea has been made to have a new look at the concept of productivity so as to make it broad based to project productivity of a system as against the productivity of a cause-effect relationship. A new approach (P-O-P) has been proposed. P-O-P approach recommends productivity measurement related to the performance objectives. It treats organisation as a system and does not view Labour, Capital etc. as inputs in the traditional sense.

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Evaluating Service Function

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In this paper an effort has been made to formulate a complete plan for evaluating/auditing the present state of productivity efforts in a service function and the paper focusses on issues concerning the factor components for productivity and performance measurement.

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Introduction

In the present day complex and competitive Industrial environment all organisations are getting more and more concerned with productivity and growth. Considerable importance is thus being attached to emphasising and strengthening developmental/service departments like Industrial Engineering. During the recent years, the strategic plans of organisations have been including establishment of Work Study/Industrial Engineering/Management Services/Corporate Planning/Productivity Services departments in order to streamline and strengthen their efforts in this direction. The primary task of such departments as Work Study/Industrial Engineering/ Management Services etc. is to act as an effective tool in channelising the energy at various levels of an organisation for its conservation and effective utilisation of the scarce resources for the benefit of mankind. Further, apex organisations and professional bodies such as BPE, FICCI, ASSOCHEM, AIEI, SCOPE, FECCI, NPC, Management Institutes, NITIE etc. have been reiterating the need for such departments for the survival and growth of organisations through different seminars/workshops.

Now that such developmental and supporting departments have come into existence in our organisations mainly to integrate and achieve productivity objectives with the organisational performance objectives, there exists an imperative need to evaluate the

performance of such functions/departments with a view to reorganising the same for realising desired contribution to the organisation. It is timely that organisations introspect and audit the total effort in the direction of productivity improvements and evaluate the outcome with a view to identifying factors impending productivity improvements and take corrective actions for achieving new heights of performance and productivity.

In this paper an effort has been made in formulating a complete plan for evaluating/auditing the present state of productivity efforts in the organisation to assess the vigour and thrust in this direction. The plan brings out the factors responsible for poor productivity performance and also pin-points the remedial action. The details of the plan is elaborated below :

Objectives of I.E. Function

Realistic evaluation of a function can be done only when its desired objectives are clearly laid down. Hence, it is necessary to examine the broad framework of objectives that are set before such developmental and service functions like Work Study/Management Services.

Basically, IE function being a support activity to the organisation aims at strengthening the organisational efforts to bring about Productivity change in organisation. The broad objectives structure includes :

* Inculcating/developing Productivity consciousness and fostering Productivity drive in the organisation and bringing about positive attitude to change.
* Facilitating the management in planning for and taking suitable actions for productivity improvement.
* Enabling the management by devicing and implementing suitable systems for controlling the actions towards productivity improvements, and
* Supplementing the organisational efforts in enhancing the technical and managerial skills of the organisation through dissemination of knowledge, information and other related issues.

In a nutshell, the IE Department/Productivity Services Dept. strives to improve the quality of management efforts towards productivity and performance improvement. Thus, in essence, any evaluation of the IE/Productivity Services function would mean the evaluation of the quality of management efforts towards bringing about productivity and performance change in the organisation.

A Mechanism for Evaluating I.E. Function

Like any other evaluating system, the Audit of IE also has four distinct phases namely—

(i) Deciding the purpose of evaluation (usually to improve productivity methods and practices)

(ii) Working out a structure or national standards/ norms and bench mark performance in various factor components of productivity (like an evaluating plan)

(iii) Comparing performance with standards or bench marks (as an evaluation)

(iv) Identification of weaker areas and implementing corrective measures for deviations/ variances.

A method of evaluating productivity as suggested in this paper is somewhat similar to the method adopted in traditional quantitative job-evaluation systems like 'Point Rated System'. This system is rather a general one to that extent but it is systematic and tries to assess quantitatively the quality and effectiveness of total productivity efforts in the organisation (as supported by the IE Department).

Evaluation Plan

Any plan for evaluation/audit of IE function should concentrate on the fact that such functions in an organisation basically aim at inculcating positive attitude towards productivity by facilitating the line management in planning and taking appropriate action for productivity and performance improvements and also by devising ways and means for controlling the same to the desired targets. In that sense, the IE department attempts to bring in the dimension of productivity in

the total management process in the organisation. The total organisational effort for productivity improvement has therefore to be evaluated under three basic parameters namely, ATTITUDE of the organisation towards productivity needs which gets translated into ACTIONS for productivity improvements and the CONTROL mechanism for corrective actions. In formulating the evaluation plan the different factors under each of the three basic parameters are identified and defined. The basic structure of the plan is depicted in the next page.

STRUCTURE OF ORGANISATIONAL FACTORS RESPONSIBLE FOR PRODUCTIVITY PERFORMANCE

Organisation's Attitude Towards—→ Productivity		Which gets translated—→ into	Actions for Productivity—→ Improvements		Which for controllable—→ through	Control Mechanism for Prdty. Improvements	
Which can be judged by evaluating factors: like	30		Which get reflected in the following factors:	50		Which can be evaluated by the following factors:	20
1. Policy for Productivity Targetting	10		Setting of Standards/ Targets	15		Feedback Mechanism (Control/Reporting System)	10
2. Policy for Actions on Productivity Improvement	10		Utilisation of Resources (Capital & Human)	15		Accounting of Responsibility for Productivity Improvement	10
3. Union's Attitude/ Participation in Productivity Improvement	5		Dev. of Resources- R & D, HRD etc. (Capital, Technology, Human & Operating System)	10			
4. Sharing the Gains of Productivity	5		Social Responsibility- external environment	5			
5.			Safety	5			

The relative weightage of the various factors that constitute the attitudinal development, actions for productivity improvement and control machinery have been suggested in the above structure. A suggested definition of each factor including the nature of issues that comprise the factor towards productivity performance are indicated at Annexure.

Like the degree concept used in job evaluation system each factor is arranged in a rating scale having different standards of achievement as bench marks. Such standards are given point-values in arithmatic progression to evolve a rating plan of the following type :—

The definition of these degrees and identification of standards/bench marks is an intricate and exhaustive task and should be switched to local requirements/ conditions of the organisations and specific functions of IE/PS Department. Those managers undertaking internal evaluation of their organisations, should use these bench marks as guidelines and use their personal judgement and internal information to determine, the level of performance achieved in that organisational factor. As for example the first degree under factor "Policy for Productivity Targetting" may be defined as "No clear-cut policy statement and no formal productivity targetting". While the fifth or last factor may be defined as Productivity policy integrated with overall organisation objectives and productivity targetting at all levels of management". Within these two extremes the other three degrees may be defined

S. No.	Organisational Factors	Weightage	Degree-Points I	II	III	IV	V
	Attitudes						
1.	Policy for Productivity Targetting	10	10	20	30	40	50
2.	Policy Actions on Productivity Improve.	10	10	20	30	40	50
3.	Union's attitude/participation in Prdty. Improvement	5	5	10	15	20	25
4.	Sharing the Gains of Productivity	5	5	10	15	20	25
	Actions						
5.	Setting of Standards/Targets	15	15	30	45	60	75
6.	Utilisation of Resources (Capital & Human)	15	15	30	45	60	75
7.	Dev. of Resources-R & D, HRD etc. (Capital, Technology, Human & Operating System)	10	10	20	30	40	50
8.	Social Responsibility external environment	5	5	10	15	20	25
9.	Safety	5	5	10	15	20	25
	Control						
10.	Feedback Mechanism (Control reporting sys.)	10	10	20	30	40	50
11.	Accounting of Responsibility for Prdty. Imp.	10	10	20	30	40	50
			100	200	300	400	500

accordingly. While five degrees have been given for each of the eleven factors in the plan, in formulating the actual plan for a particular organisation the number of degrees may change depending on the present state and the various achievable steps or degrees within that factor.

Once the plan is formulated and degrees defined, the evaluation process is carried out through data collected for the present state of each factor and assigning values as per plan. The normal procedure of any job Evaluation Programme may be followed in general with special emphasis in bringing out the information for various levels of management specially the top management.

Conclusion

The evaluation plan elaborated in this paper has been basically translated in this form from a conceptral frame work and it may need certain modifications/ improvements which can be incorporated after gaining sufficient experience through actual application. Besides being a valuable tool in evaluating the productivity efforts of an organisation, this plan can be used for interfirm and intra-firm comparison. Giant Public/ Private sector organisations like SAIL, BHEL, TATAs etc. and apex bodies like BPE, NPC, NITIE etc. can jointly undertake projects in the direction for developing and standardising such evaluation plans.

ANNEXURE

Factor Components of Productivity Performance

The issues concerning the factor components of productivity performance and functioning of the service and support departments such as I.E. Department that would lead to defining the factors as well as its degrees and identifying bench marks/standards for the degrees are outlined below. However, it may be noted that

this is not exhaustive but only a suggestive check list which requires to be discussed further for making it more comprehensive for adopting it to the requirements of various organisations.

A. Organisational Attitude to Productivity

1. *Policy for Productivity Targetting*

This factor relates to management's attitude and efforts in formulating policies for productivity improvements and targets at various levels of the organisation—right from overall organisation targets down to shop-floor level for each activity centre and how these targets are interlinked for achieving overall organisation targets.

* Is the policy based on adhocism/government directives/social needs/scientific assessment ?
* Does the policy change frequently with the change in top management/ruling party ?
* Are these policies in line with the overall objectives of the organisation ?
* Is there an awareness among the management and staff of these policies ? etc.

2. *Policy for Actions on Productivity Improvements*

* Who is responsible for productivity improvement ?
* What is the organisation set up to achieve this?
* What are the service functions available for this purpose—PPC, IE, Mgmt. Services, EDP, etc. ?
* What are the reporting relationships ?
* Are the authority and accountability relationships clearly defined ?
* What is the ratio of line staff to service staff (IE/PPC etc.) ?
* Productivity effort wholly internal or outside consultancy availed ?
* Performance of service functions evaluated ?
* Any cost benefit analysis done for productivity efforts ?
* Is Management action for productivity improvement channelised in right direction—is management concerned with 'A' items of the costs ?

3. *Unions Attitude/Participation in Productivity Improvements*

* What is the involvement (interference/assistance) of unions in productivity improvements ?
* Do union management committees at shop level and higher ups exist ? If so, what is the effectiveness ?
* State of industrial relation—is it congenial for productivity improvement ?
* What is the extent of influences of unions on managerial decisions ?
* What is the effectiveness of Statutory Committees like Works Committee, Labour Relation Committee etc. ?
* What is the awareness among unions and their members of the need of productivity improvements ?
* What is the extent of management's and union's effort to educate employees in this area ?

4. *Sharing the Gains of Productivity*

* What schemes exist ?
* What is management's and union's attitude ?
* Does it motivate workers and management to improve productivity ?
* Does it lead to frequent labour unrest-specially during process period ?

B. Actions for Productivity Improvement

1. Setting of Standards/Targets

Sub-factors : Output, Performance, Manpower, Material, Machines

Level : Overall organisation, Deptt./Division, Section, Industrial jobs

Basis : Adhoc/Historical/Negotiations with Unions/One time exercise through consultants/continuous process through scientific studies

Use : Planning/Production Targetting/Incentive Scheme/Performance Monitoring

2. Utilisation of Resources

Sub-factors : Plant/Machine Capacity, Manpower, Material, Power etc.

% Utilisation of these sub-factors can be divided and put in the rating scale.

3. Development of Resources

Sub-factors	*Extent of Mgt. Effort in Development*
Manpower skill/ creativity	Training, Job rotation, suggestion scheme, Reward scheme, HRD
Material	Standardisation, Import substitution, Cost reduction
System & Procedures	O & M, Systems Studies
Design & Development	Methods improvement, Value Engg., Process Studies, Machine Tool Design
R & D	Effort of R & D in relation to above & technological improvement.

4. Social Responsibility

* What is the control on price of the product ?
* Does it keep on increasing to cover up inefficiency and show profit ?
* Are dividends paid to Govt. on equity capital ? If so, how much ?
* What are the welfare facilities to employees—is it upto their satisfaction ?
* Development of enterpreneurship and ancillary industries around the factory ?
* Anti-pollution activities ?
* Service to society at large through institutions like schools, hospitals etc. and adopting villages.

5. Safety

* Safety consciousness ?
* Extent of training/campaign/safety measures undertaken ?
* Production at the cost of safety ?
* Rate of accidents ?
* Is safety considered as an integral part of productivity efforts ?

C. Control Mechanism

1. Feedback Mechanism

* How is the flow of information for control on productivity ?
* Does any regular system exist ?
* Any action taken on feed-back ? or
* reports are made and filed ?
* Actions are taken at shop level or directives have necessity to come from the top ?
* Any system of budgeting control, performance monitoring etc. exist ?
* What is their effectiveness ?
* Regular meetings at shop level/higher ups held and corrective actions taken for productivity improvement ?
* Are targets revised downwards so that they can be achieved ?

2. Accounting of Responsibility for Productivity Improvements

* Who is responsible for productivity improvements ?
* Is the performance related to individual's annual appraisal ?
* Does it affect his career progression/growth in the organisation ?
* What are the reward/punishment systems ?
* Can a person get away with excuses for his failures ?
* To what extent service function (IE, PPC, Mgt. Services etc.) are responsible and accountable for productivity improvements/failure ?

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Size Productivity Relationship in Tea Industry

SIB RAJAN MISHRA

The present study makes an attempt to examine whether the scale of operations makes differences to the efficiency of the use of the inputs for production of a perennial crop like tea.

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Though the debate on the relationship between size and efficiency has been engaging the attention of the economists for over two decades,[1] yet an enquiry of this type hitherto remains unanalysed in the case of tea industry. In this paper, attempt is made to examine this issue. This problem is of paramount importance. It is essential that the units of production should be organised on the most economic scale which can secure the greatest economies of production and distribution. If, for instance, units are found small and unwieldy for efficient and economical working the efficiency of the industry will be seriously impaired. The failures of such ill-conceived or uneconomic units may lead to frittering away of national resources, may demoralize the entire investment market and may throw a large number of workers out of employment and finally, may threaten the stability and smooth working of the economic system. In the larger interests of the national economy, units should be properly reorganized and consolidated in a proper way.

For our analysis, we have chosen 'area' as the determinant of size. Here 'area' denotes the actual area cultivated under tea and not the total area under the ownership of the concern. The choice of area has been done mainly because it is the cultivated area that makes

1. By subjecting the Farm Management data on production, size etc. Economists like A.K. Sen, A.M. Khusro, Asok Radra, C.H. Hanumantha Rao confirmed the existence of inverse relationship between farm size and productivity.

the effective contribution to the production. For measuring efficiency in this context, we have taken 'yield per hectare' as the basis. Of course, the rate of profit, labour productivity of cost of production are also being used as indices of efficiency. But there are insuperable difficulties to formulate a correct definition of profit which will command universal acceptance, mainly because of difficulty of distinguishing profits from other types of income, because of widely divergent accounting practices pursued by individual units and ingenious methods adopted by a section of unscrupulous producers to deliberately conceal or manipulate the true financial position of the concern. As regards costs of production, there is also lack of data. Another difficulty is with regard to the intercomparison of the cost of production of different units. This may be largely due to the fact that the different units may derive differential advantages due to locational disparities, the varying rates of wages, the condition of labour in different parts, difference in the character of technical equipment etc. It is difficult to determine with any degree of precision and exactitude the amount of cost. In sum, not only is in there a deplorable lack of statistical data relating to profit or cost of production but also the limited data available, are not readily adaptable to the use of an analyst.

However, our choice of yield as the basis of efficiency is not free from defect. Since a particular quantity of yield per hectare may be economic or not depends upon the prevailing price level.

Sources of statistical informations

An enquiry of this type obviously involves collection and analysis of large mass of data. Yield is influenced by a variety of factors such as location, agro-climatic conditions, degree of mechanization etc. So, it is not reasonable to conclude that size and size alone, rather than other factors, explains the comparative efficiency of different sized units. That is why, it appears that the locational disparities in soil-climatic conditions and other differences arising from local environments of the industry may be so great that the locational factors may tend to conceal or distort the true character of the relation between the two variables.

We have, for this purpose, selected the tea plantations situated in Terai-Dooars. Environmental conditions prevailing in Dooars and Terai are almost uniform and homogeneous. This greater degree of uniformity in environmental conditions will greatly facilitate the intercomparison of data and reveal more distinctly the character of the relationship. After a critical study of the factual data, we have chosen 40 plantations out of 197 plantations in total situated in Terai and Dooars randomly, 10 from each of the four size classes (i.e size class-(i) below 100 hectares (ii) above 200 and below 400 hectares (iii) above 100 and below 200 hectares and (iv) above 400 hectares). A large field is covered and so, fairly representative in character. We have computed the required data from the Returns containing informations on area, yield and other particulars, which are required to be submitted annually by each plantation unit to the Tea Board, Calcutta. The data pertain to the period 1977.

Results and discussions

The above may be interpreted as four random samples of size $n_1 = n_2 = n_3 = n_4 = 10$ with means (average yield) $Y_1 = 540$ kg; $Y_2 = 950$ kg, $Y_3 = 1,190$ kg, and $Y_4 = 1,510$ kg per hectare. We wish to establish with the help of analysis of variance whether there is a significant difference in the average yield of the four different size-classes.

The null and alternative hypotheses are

$$H_0 : Y_1 = Y_2 = Y_3 = Y_4 = Y_1$$

H_1 : Y_1's are not all equal.

With the informations available, the following analysis of variance table was set up :

Table

Analysis of variance for size-efficiency relationship

Sources of variance	Sum of squares	Degrees of freedom	Mean of sum of squares	F-ratios
Between the samples	4,50,784	3	1,50,261	25.14
Within the samples	2,09,752	36	5,826	
Total	6,60,537	39		

The observed value of F* (25.14) is much higher than the tabulated value of F at one per cent level (F_{01} = 4.31) with 3 and 36 degrees of freedom. So, we reject the null hypothesis and conclude that the average yield of the different size-classes are not all equal. This leads to the question : are some average yields equal and some different from each other ? To do this, we perform the pair-wise comparison or critical difference test to know which of the yields of the size-classes are different from each other and equal.

To perform this, we use the following formula[2] :

$$| Y_i - Y_j | \geqslant \sqrt{2n_o \, S\,E\, F_{n-a}\,(0.05)}$$

where Y_i and Y_j are sample totals,

S E is $\frac{SE}{n-a}$, the mean squares of within source of variation

F_{n-a} (0.05) is the Table value of F at 5 per cent level of significance, and

n_o number of observations in a sample.

Let us present the differences of the sample total $| Y_i - Y_j |$ in the following table.

	Y_4	Y_2	Y_3	Y_1
Y_1				
Y_2	4,100			
Y_3	6,500	2,400		
Y_4	9,700	5,600	3,200	

The right hand side of the formula

$$(\sqrt{2n_o \, SE\, F_{n-a}\,(0.05 \text{ or } 0.01)}$$

because for all the combinations (Y_1, Y_2), (Y_1, Y_3), (Y_1, Y_4), (Y_2, Y_4) and (Y_3, Y_4) less than the differences ($Y_i - Y_j$) for 5 per cent and 1 per cent levels of significance. This shows that the average yield of all the size-classes are significantly different from each other. Again, since the data reveal that there is an increasing tendency of yield with the increase in size of the plantations, we may conclude that there is a positive relation between size and yield.

Though the type of negative relationship between farm size and yield (or efficiency) seems to remain confirmed in a large number of studies in the cases of annual crops, our statistical evidence points to the existence of positive relationship. "The yield has some relationship to the size of the estates being generally higher in the larger estates".[3] Similarly, the Report of the official Team on the tea Industry (1952)[4] and the Report of the Special Officer for Cachar and Tripura (1954)[5] have also observed that a unit of production may be uneconomic by nature from the point of view of efficiency if the size of the plant is small. K.G. Sivaswamy in his dissenting note in the Plantation Inquiry Commission's Report[6] has considered that the estates between 100 and 300 acres irrespective of the region, should be classified as uneconomic. R.D. Morrison's on Memorandum on Tea (1954)[7] has defined an economic unit as anything from three hundred to three thousand acres in extent".

Of course, this relationship does not necessarily imply that all large-sized units are more efficient than the small-sized units. If we examine the data, we might at once discover that many small-sized units in Dooars and Terai have higher yields than some other large-sized plantations. This conclusion can, however, be viewed as an indicative of general tendencies. No firm conclusion can be drawn about the effect of area on yield of a unit of production on the basis of pure across-the-fields comparison of yield simply because (1) size is not the only factor which determines the yield. Yield is the product of a large variety of factors, such as extent of technical efficiency achieved, advantages of location, degrees of financial, adminis-

2. Yamene, Taro—Statistics—An introductory analysis. Harper International Edition, (3rd edition), p. 843.

3. Report of the Comittee on tea marketing (appointed by the Government of India), New Delhi, 1980.

4. Report of the Official Team on the Tea Industry (New Delhi), 1952, p. 32.

5. Report of the Special officer for Cachar and Tripura on Tea, 1954.

6. Plantation Inquiry Commission's Report, Government of India, New Delhi—1956, p. 364.

7. Tea Memorandum relating to the Tea Industry and Tea Trade of the World, (London, 1943), p. 9.

trative and managerial integration. Not all of these are common to all the units of different sizes. Some of the small plantations may be able to achieve some advantages and may thus be able to counteract some of the diseconomies of small size. (ii) Secondly, by the very nature of historical development of plantations, the best areas, were planted first in large area and cultivation was later extended to less productive areas.

However, we may offer some explanation for this phenomenon. The significant difference in productivity among tea plantations may be due to the fact that there is an inefficient use of resources in some plantations; there may exist some unexploited potentials for increasing production in some plantations. It is true that the large tea plantations normally enjoy some economies of scale. They can achieve more advantageous specialization of plant and machineries. They can have processing factories on or near the estates. In other words productivity may increase due to vertical integration of productive units, implying the combination of ownership of landholdings, factories and transport arrangement in a single hand. Improved methods, including effective control measures, replantation of the old bushes and other extensive rehabilitation programme will need a huge investment which normally large estates afford to do. More effectively, they may get capital easily at convenient terms.

Large-sized and more prosperous plantations have more efficient utilisation of manpower and better planning and lay out. Management may also be treated as an independent variable along with capital and labour for increasing productivity. Qualitative aspect i.e. loving care of management factor may also inspire the large tea estates to boost up the level of productivity. Closer attention and supervision at each stage which plucking process needs, will help to increase the productivity. Professor Sargant Florence[8] has rightly laid down a bold proposition:

"There are logical reasons for supposing that, granting the advantages of mechanical and human specialization, large scale production especially when conducted in large scale firms and plants, results in maximum efficiency".

In considering the efficiency of a unit of production, optimum utilisation of the factory is important, and to sustain an optimum utilisation of a factory, a certain quantity of tea leaves is essential. The extent of idle capacity of a factory explains the degree of scarcity of tea leaves. And if the cause of scarcity is attributed, to among others,, to smallness in size, naturally the remedy suggested would be the enlargement of the area. But there are geographical and other constrainsts for the enlargement of the plantations. The logical implication of this finding is that productivity of land would increase if the existing structure of size is reorganized so that a good combination of size of the plantations and factory is ensured.

8. Florence, Sargant – Logic of Industrial organisation, London, 1933. p. 11.

Productivity
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Capacity Utilisation in Cement Industry

SUSHIL J. LALWANI

This paper analyses productivity trends in cement industry with special reference to capacity utilisation. According to the author variations in productivity in cement industry are mainly due to fluctuating performance of the Power sector, coal a Railway sectors. Labour unrest had an insignificant impact on production but power cut, coal and mechanical troubles affected productivity to a great extent.

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Utilisation of capacity is an important measure of productivity, particularly for under-developed and developing countries. Such countries are mostly confronted with infra-structure bottlenecks which make it difficult to achieve full rate of capacity-utilisation in different industries. In this context, therefore, productivity is the optimum utilisation of resources put into the production process. In its broad sense, the word 'productivity' includes various activities aimed at improvement. As the country-Report-India presented by the Asian Productivity Organisation, 1980, puts it, "Productivity envelopes all activities aimed at improving the quality of life in the national economy."[1]

The paper has been written along lines suggested by Professor K.T. Chandy. The object of this paper analysis productivity trends in cement industry with special reference to capacity utilisation.

Methodology: Capacity utilisation, as a measure of productivity, refers to output as a percentage of the installed or the licenced capacity, whichever is lower. In other words the ratio between output and installed/ licenced capacity of a cement unit is defined as its productivity.

This study gives capacity utilisation rates (in percentages) for the private sector, public sector and

1. Chandy, K.T., Factors which Hinder or Help Productivity Improvement. APO, Tokyo, 1980 p. 2.

Industry as a whole. This is a study of 15 cement units which covers a period of 12 years, from 1970 to 1981. It covers 12 cement companies in the private sector and 3 cement companies in the Public sector. No logical criteria was adopted to select the companies included in the sample. The selection of these units was largely based on availability of Balance-sheets, available with the Cement Manufacturers' Association, Delhi, wherein data on capacity and production are available.

First of all, average productivity has been studied. Then increase or decrease in productivity in a number of units has been analysed. The 12 companies selected from the private sector having 29 factories with a capacity of 139.04 lakh tonnes are : The Andhra Cement Co. Ltd., The Associated Cement Companies Ltd., Bagalkot Udyog Ltd., Chettinad Cement Corporation Ltd., The India Cements Ltd., The Jaipur Udyog Ltd., Kalyanpur Lime & Cement Works Ltd., Madras Cements Ltd., Mysore Cements Ltd., Saurashtra Cement & Chemical Industries Ltd., Sonevalley Portland Cement Co., Ltd., and the Travancore Cements Ltd. 3 *public sector* companies with 10 factories having a capacity of 27.60 lakh tonnes been included, namely, The Cement Corporation of India Ltd., The Tamil Nadu Cements Corporation Ltd,, The U.P. Cements Coroporation Ltd. This makes a total of 15 cement companies.

An Improvement : In our study, data on installed or licenced capacity whichever is lower has been taken. Mostly data on installed capacity are available but only in a few cases licenced capacity has been used when it was lower than the installed capacity. This has an improvement over the study undertaken by *Goel and Nair* which was based on licenced capacity and the rate of capacity utilisation was calculated as a ratio between output and licenced capacity. In their Data-Limitation also they stated that,

"the available sources of data provide information only regarding what is called licenced capacity. Industry level data on installed capacity are not available, since licenced capacity is only a concept on paper, it is not necessary that this be equal to the installed capacity, a priori. However, in the absence of any further information on the gap between these two, licenced capacity has been reckoned as installed capacity for the purpose of present analysis."[2]

Why measure of 'Capacity Utilisation' in Cement Industry

The profitability of any industry depends a great deal on the capacity utilisation achieved. In the case of a hightly capital intensive industry like cement, with heavy fixed charges and various constraints like labour trouble, power cuts, nonavailability of coal and railway wagons to transport coal, this factor of capacity utilisation assumes even greater importance.

The Cement Industry is heavily dependent upon the efficient functioning of the following three infrastructure industries :—

(i) Power
(ii) Coal, and
(iii) rail transport.

These industries require heavy investment and generally suffer from the following :—

(i) Poor management
(ii) labour unrest
(iii) natural calamities
(iv) limited resources with the economy to exploit the sectors beneficially.

These drawbacks are the major hinderances to proper capacity utilisation.

Besides, there are many other factors affecting capacity utilisation and the loss of cement production on account of shortage of coal, power cuts/failures, short supply of Railway Wagons (External)—was 37% of total loss in 1970, 43% in 1971, 53% in 1972, 71% in 1973, 81% in 1974, 52% in 1975, 19.90% in1976 and 26.24% in 1977. Loss of cement on account of internal factors like shortage of Raw material. mechanical trouble, repairs of Mills, Kiln Breakdown, Teething

2. V.K. Goel & N.K. Nair, Productivity Trends in Cement Industry in India, NPC, New Delhi, 1978, p. 10 (i).

trouble, labour troubles, lay offs was 39% of total loss in 1970, 38% in 1971, 42% in 1972, 25% in 1973, 16% in 1974, 41% in 1975, 64.10% in 1976, 69.20% in 1977. The total loss of production in million tonnes was 2.96 in 1970, 3.91 in 1971, 3.47 in 1972, 4.28 in 1973, 4.12 in 1974, 3.34 in 1975, 2.19 in 1976, 2.31 in 1977, 3.58 in 1978 and 7.55 in 1980.

It is clear that factors external to cement industry had a lion's share for the period 1970-77. The share of these factors declined during the years 1976 and 1977 or utilisation increased.

Achieving a high rate of capacity utilisation then, will reflect efficiency of a unit or industry as a whole. Therefore, capacity utilisation will be an indicator of efficiency and productivity both. We have used the concept of capacity utilisation as a measure of productivity on following grounds :—

(a) the cement industry is confronted with the infrastructure bottlenecks affecting the rate of capacity utilisation. Hence a study based on the concept of capacity utilisation can better indicate the productivity gains or shortfalls.

(b) Data on cost and inputs like limestone, gypsum bauxite, coal etc. are not separately available, therefore, adopting total factor productivity and value added methods will present problem of deflation of their prices and calculations. Prices of these raw materials or price index at unit level are not available.

(c) Data on and study on Macro-level basis are available whereas on Micro-basis or unit wise capacity utilisation studies have not been undertaken.

Productivity Trends : Macro Level

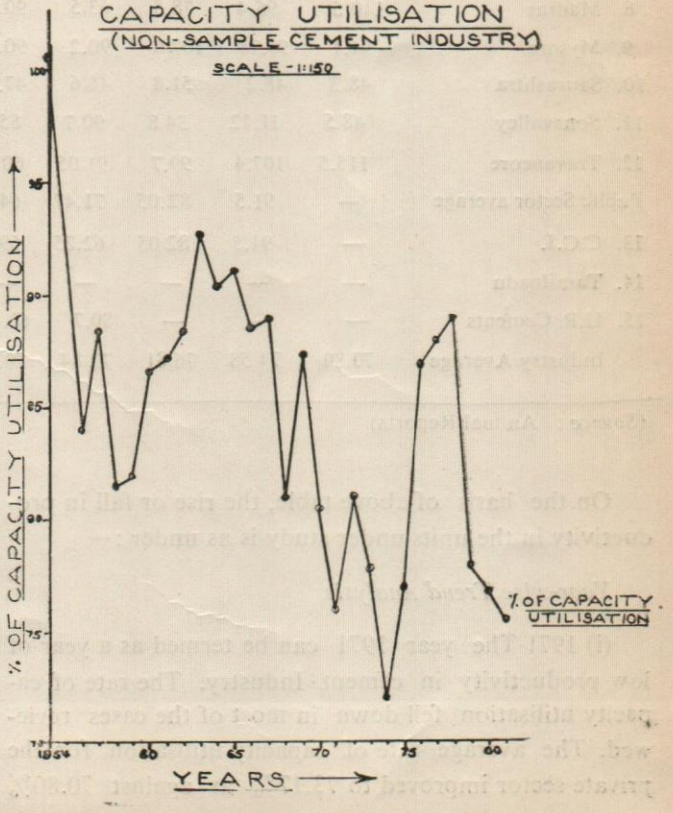
Rate in Percentage of capacity utilisation in the Cement Industry is given below :—

In 1954, the rate of capacity utilisation was 100.4% which fell down to 83.9% in 1956. Then upto 1965, leaving 1958 and 1959, its tendency was towards improvement but again the rate went on falling till 1971. Itagain improved during the years 1975-78, which was

Table showing capacity utilisation in Indian Cement Industry 1954-1980

Year	% of capacity utilisation	Year	% of capacity utilisation
1954	100.4	1968	80.9
1955	92.6	1969	87.3
1956	83.9	1970	80.4
1957	88.3	1971	76.0
1958	81.4	1972	81.0
1959	81.8	1973	77.8
1960	86.5	1974	72.0
1961	87.1	1975	77.0
1962	88.3	1976	87.0
1963	92.7	1977	88.0
1964	90.3	1078	89.0
1965	91.1	1979	78.0
1966	88.5	1980	76.9
1967	28.9	1981	75.6

Source: Cement Production & Despatches, Govt. of India, Delhi.



an exceptional period when all sectors of the economy were in better shape. It registered a fall again during the years 1979 and 1980.

Productivity Trends : Micro Level :

Given below is the capacity utilisation rate for a sample of 15 units that has been calculated yearwise i.e. from the year 1970 to 1981.

in 1970. In the public sector the cement Corporation of India started production and its capacity utilisation rate was 91.5%. The rate of capacity utilisation for the Industry as a whole came to 74.58%.

Out of 11 units studied, 7 units had a decline in productivity or the rate of capacity utilisation, whereas rest of the *four units* had an increase in productivity. Units having an increase were namely, Bagalkot,

Capacity Utilisation in Cement Industry—Unit-wise Output as a % of installed/licenced capacity

SN Units	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Private Sector Average	70.80	73.17	76.38	73.06	71.17	73.57	64.42	78.66	80.44	82.59	68.87	68.56
1. Andhra	78.4	77.6	80.9	61.6	88.2	83.5	100.7	116.2	96.5	117.7	58.09	60.43
2. A.C.C.	87.9	81.1	77.3	77.08	78.5	85.3	92.2	91.9	93.2	89.06	74.1	78.9
3. Bagalkot	57.7	61.6	61.5	74.7	53.05	64.1	59.7	48.3	51.6	82.37	43.42	86.72
4. Chettinad	50.0	51.6	62.6	38.06	46.1	66.6	75.6	86.9	100.2	90.5	82.06	96.8
5. India	65.4	77.8	86.9	83.4	68.9	68.3	88.3	88.02	90.1	101.2	79.5	73.4
6. Jaipur	100.4	93.62	102.06	80.9	65.9	54.9	0.11	83.06	78.04	77.7	50.9	58.6
7. Kalyanpur	—	71.9	72.8	77.4	79.02	84.8	81.1	78.04	88.43	88.2		80.0
8. Madras	110.5	96.4	78.5	63.5	90.5	74.6	105.4	67.06	80.2	88.6	107.4	123.2
9. Mysore	91.1	99.78	107.6	90.2	90.9	92.7	108.2	79.1	87.03	84.8	70.3	84.8
10. Saurashtra	48.3	48.2	51.8	48.6	47.1	68.4	59.9	60.3	57.01	46.6	51.61	43.08
11. Sonevalley	48.5	11.12	34.8	90.7	85.5	79.1	65.7	31.2	72.5	50.4	60.7	55.6
12. Travancore	115.5	107.4	99.7	91.05	60.4	60.6	61.1	68.68	70·5	73.62	75.6	80.06
Public Sector average	—	91.5	82.05	71.47	64.75	64.2	82.7	83.1	73.2	69.3	59.79	70.9
13. C.C.I.	—	91.5	82.05	62.25	69.9	68.2	86.0	87.2	73.8	61.9	76.29	81.1
14. Tamilnadu	—	—	—	—	—	—	—	84.6	77.2	79.8	43.3	60.8
15. U.P. Cements	—	—	—	80.7	63.6	60.2	79.3	77.5	68.8	66.2	—	—
Industry Average	70.80	74.58	76.81	72.84	70.25	72.23	64.38	79.55	79.0	79.93	67.57	68.85

(*Source* : Annual Reports)

On the basis of above table, the rise or fall in productivity in the units under study is as under :—

Year-wise Trend Analysis

(i) 1971-The year 1971 can be termed as a year of low productivity in cement Industry. The rate of capacity utilisation fell down in most of the cases reviewed. The average rate of capacity utilisation for the private sector improved to 73.17% as against 70.80%

Chettinad, India and Mysore. Units having a decrease were, namely; Andhra, the A.C.C., Jaipur, Madras, Saurashtra, Sone valley and Travancore.

1972 : The average rate of capacity utilisation in the *private sector* was 76.38% as against 73.17% in 1971. The *public sector* average fell down to 82.05% as compared to 91.5% in 1971. However, the *Industry* average improved to 76.81% as against 74.58% in 1971.

Years	Number of units having increase	Number of Units having decrease
1971	7	4
1972	5	8
1973	10	3
1974	6	8
1975	5	8
1976	5	9
1977	8	6
1978	6	9
1979	9	6
1980	9	5
1981	3	11

Out of 13 units under review, *productivity increased in 8 units and dccreased in 5 units*. Out of the 8 units having an increase, 3 units were the same who had an increase in productivity in the previous year also. Such units were, namely, *Chettinad, India and Mysore*. Rest of the *five units* having an increase in productivity were, namely, *Andhra, Jaipur, Kalyanpur, Saurashtra and Sone valley*. Productivtty declined in *5 units* namely, *the A.C.C., Bagalkot, Madras, Travancore and the C.C.I.* The A.C.C. and Madras had a decline in the rate of capacity utilisation even last year also.

1973 : The *private sector average* rate of capacity utilisation fell down to 73.06% as against 76.38% in the previous year, the *public sector* average came down to 71.47% as against 82.05% in 1972 and there was an overall decline that the *Industry* average also fell down to 72.84% as compared to 76.81% in the previous year.

Out of *13 units* under review, productivity increased in case of *3 units* only where as it decreased in case of *10 units. 2 units out of the 3 units* having an increase were the same who had an increase in productivity last year, namely *Kalyanpur and Sonevalley*. 3rd unit to have an increase was Bagalkot. *4 Units* of the *10 units* having a decline had a decline last year also, namely, *the A.C.C., Madras, Travancore and* the C.C.I. Rest of the 6 units having a productivity fall were, Andhra, Chettinad, India, Jaipur, Mysore and Saurashtra.

1974 : There was an overall decline in productivity. The *private sector* average capacity utilisation fell down to 71.17% as against 73.06% in 1973, the *public sector* average *fell down* to 64.75% as compared to 71.47% and Industry average also came down to 70.25% as against 72.84% in the previous year.

Out of the 14 units studied, productivity rose in *8 units* but *declined in 6 units*. Out of the *8 units* having an increase in productivity, *Kalyanpur* maintained the increase since *1972*. Rest of the units were, namely, the *Andhra, the A.C.C. Chettinad, India, Madras, Mysore, and* the C.C.I. Similarly, out of the *6 units*, having a decline in productivity were *Bagalkot, Jaipur, Saurashtra, Travancore and the U.P. Cements Corpn. 3 units* out of above *6 units* had a decline even last year, namely, *Jaipur, Saurashtra and Travancore*.

1975 : The average rate of capacity utilisation in the *private sector increased* to 73.57% as against 71.17% in the previous year, in *public sector* it delclined to 64.2% as against *64.75%* in 1974, but the *Industry* average improved to *72.23%* as against 70.25% in the previous year.

Out of the *14 units studied, the Productivity increased* in case of 8 *units* and *declined* in 6 units. Last year also, the productivity rose in *8 units* and declined in 6 units but these were not the same units. *Out of 8 units* having a rise in productivity, 5 units were the same in the previous year. namely, *the A.C:C., Chettinad, Kalyanpur (since 1972) Mysore and the C.C.I.* Out of the *6 units* having a decline, *3 units* were common in 1974, namely, *Jaipur Sonevalley and* the U.P. Cements. Rest of the *3 units were Andhra , India and Madras*.

1976 : There was a productivity decline in the *private sector* but improvement in the *public sector*. The rate of capacity utilisation in the *private sector* fell down to 64.42% as against 73.57% in 1975, in the *public sector*, it increased to 82.7% (64.2% in 1975) and for the *Industry* it declined to 64.38% as against 72.23% in the previous year.

Out of the *14 units* under review, the productivity rose in 9 *units* and declined in *5 units*. Of the *9 units* having an increase in productivity, 5 units had an increase in the previous year, and *4 units out of 5 units* had an increase in productivity since 1974, namely, Chettinad, the A.C.C., Mysore, and the C.C.I. Fifth unit was Travancore, rest of the 4 units having a rise were, namely, *Andhra, India, Madras and the U.P. Cements.* 5 units having a decline were, namely, *Jaipur (decline since 1973), Kalyanpur, Bagalkot, Saurashtra and Sonevalley* (decline since 1974).

1977 : There was an overall improvement in capacity utilisation, i.e., the *private sector* average *increased* to 78.66% as against 64.22% in 1976, the *public sector* average *went up* by 0.4%, or to 83.1% as against 82.7% in 1976, and average for the *Industry* as a whole *went up* to 79.55% as against 64.38% in 1976. After 1972, such results could be obtained in 1977 only.

Out of the *14 units* reviewed, the *productivity increased* in *6 units* and *declined* in 8 units. Out of the *6 units* having an increased productivity, *4 units* had the increase in the previous year also, namely, *Andhra, Chettinad* (since 1974), *Travancore* (since 1975) and the *C.C.I.* (since 1974). Rest of the *2 units* were *Jaipur and Saurashtra.* Out of the *8 units* having a decline in productivity *3 units* were the same in 1976 also, namely, *Bagalkot, Kalyanpur and Sonevalley* (Since 1974). Rest of the 5 units were, namely, *A.C.C., India, Madras, Mysore and the U P. Cements.*

1978 : The *private sector* average rate of capacity utilisation *improved* to 80.44% as against 78.66% in the previous year whereas there was a decline in the *public sector to 73.2%* as against 83.1% in 1977, but average percentage for the *industry* as a whole improved to 80.44% as against 78.66% in 1977.

Out of *15 units* studied, the productivity increased in *9 units* and declined in *6 units.* Out of the *9 units, 2 units* had an increase in productivity in the previous year also, namely, *Chettinad and Travancore.* Rest of the *7 units* to record an increase were, namely *A.C.C., Bagalkot, India, Kalyanpur, Madras, Mysore and Sonevalley.* In other *6 units* where the productivity declined were namely, *Andhra, Jaipur, Saurashtra,, the C.C.I., Tamilnadu and the U.P. State Cement Corpn. Ltd.* (in 1977 also).

1979 : The *private sector* and the *Industry* as a whole had a higher average rate of capacity utilisation as compared to the previous year average. The *public sector* had a decline. The private sector average increased to 82.59% as against 80.44% in 1978, the *Industry average* also went up to 79.93% as against 79.0% in the previous year, whereas the public sector average *went down* to 69.3% as compared to 73.2% in 1978. For the *Cement industry* as a whole, the total loss of production on account of various factors was 5.52 million tonnes as against 3.59 M.T. in 1978 and 2.31 M.T. in 1977.

Out of the *15 units* under study, productivity increased in case of *6 units* and decreased in *9 units.* Out of the *6 units* having an increase, *4 units* had an increase even in the previous year. Such units were, *Bagalkot, India, Madras, and Travancore* (since 1975). The other *2 units* were *Andhra and Tamilnadu.* Out of *9 units* having a decline, *4 units* had the decline in 1978 also. Such units were, *Jaipur Saurashtra, the C.C.I. and the U.P. Cements.* Rest of the 5 units having a decline were namely, *A.C.C. Chettinad, Kalyanpur, Mysore and Sonevalley.*

1980 : There was a massive decline in all the three averages of capacity utilisation. The *private sector* average rate of capacity utilisation declined to 68.87% as compared to 82.59% in 1979, the *public sector* average rate of capacity utilisation fell down to 59.79% as against 69.3% in the previous year and average for *Industry* came down to 67.57 as against 79.93% in 1979. In 1980 the Cement Industry reported a *loss* of production to the tune of 7.56 million tonnes.

Out of the *14 units* under study during the year 1980, *the increase in productivity* was in *5 units* only whereas it declined in *9 units.* Out of the *5 units* having an increase in the productivity, *2 units* were the same in last year, namely, *Madras and Travancore.* The other *3 units* were, namely, Saurashtra, Sonevalley and the C.C.I. Out of the *9 units* having a decline, *5 units* had a decline in 1979 also, such units were, namely, the *A.C.C., Chettinad, Jaipur, Kalyanpur and Mysore.*

Rest of the 4 units were, *Andhra, Bagalkot, India and Tamilnadu.*

1981 : The average productivity for the *private sector* was *68.56%* as against 68.87% in 1980, the *public sector* improved to 79.9% as against 59.79% in 1980, and the *Industry* as a whole had a capacity utilisation of 68.89% as against 67.57% in the previous year.

Out of *14 units* under study during 1981, *11 units* had an increase in productivity and *3 units* had a decrease. Out of the *11 units* having an increase in productivity, only *3 units* had an increase in the previous year also. Such units were, *Madras, the C.C.I. and Travancore* (since 1975). The other *8 units* were *Andhra, A.C.C. Bagalkot, Chettinad, Jaipur, Kalyanpur, Mysore and Tamilnadu. 3 units* having a decline in the productivity were, *India* (in 1980 also), *Saurashtra* and Sonovalley.

Conclusions

The concept of productivity measurement used for this analysis was capacity-utilisation. *Capacity utilisation* indicates the overall performance of cement units. The rate of capacity utilisation is affected by a number of factors, many of them are *beyond control* of management of a unit. Mostly, external factors like, power cut, wagon shortage, coal shortage, transport bottlenecks and shortage of high grade raw materials are the major factors affecting 'total productvity' in a cement unit.

1. Out of eleven years' study undertaken, increase or decrease in productivity was as under :—

S.N.	Units	Number of years (+)	Number of years(−)
1.	Andhra	6	5
2.	A.C.C.	5	6
3.	Bagalkot	6	5
4.	Chettinad	8	3
5.	India	6	5
6.	Jaipur	3	8
7.	Kalyanpur (10)	6	4
8.	Mysore	7	4
9.	Saurashtra	4	7
10.	Sonevalley	4	7
11.	Travancore	7	4
12.	C.C.I. (10)	6	4
13.	Tamilnadu (4)	2	2
14.	U.P. State (6)	1	5
	Average	5	5

(Figures in Bracket indicate Number of years for which data were available)

2. Increase and decrease in productivity were almost equal.
3. [According to the author variations in productivity in cement industry are mainly due to fluctuating performance of the Power sector, coal and Railway sectors.
4. Labour unrest had an insignificant impact on production but power cut, coal and mechanical troubles affected productivity to a great extent.

Productivity
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Productivity Related Variables an Inter Industry Analysis

DR. V. LAKSHMANA RAO

The purpose of the paper is to examine the inter relationships between productivity on the one hand and capital intensity and managerial resources on the other.

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Using inter-industry cross-section data the following hypotheses suggested by neo-classical production theory have been tested statistically.

1. Industries with above average capital intensity will also be industries with above average labour productivity.

2. Industries with above average managerial resources will also be industries with above average labour productivity.

The statistical analysis in this paper is based on the Annual Survey of Industries (ASI) 1977-78 issued by the Central Statistical Organisation. The data relate to the factory sector. The data cover 17 two-digit industries namely Manufacture of food products (20-21), Manufacture of Beverages, Tobacco and Tobacco products (22), Manufacture of Cotton Textiles (23), Manufacture of wool, silk, and Synthetic Fibre Textiles (24), Manufacture of Jute, Hemp, and mesta Textiles (25), Manufacture of Textile products including wearing apparel (26), Manufacture of Wood and wood products, Furniture and fixtures (27), Manufacture of paper and paper products and printing and publishing and allied industries (28), Manufacture of leather and leather products (except repair) (29), Manufacture of Rubber Plastic, Petroleum and Coal products (30), Manufacture of Chemicals and chemical products except products of petroleum and coal (31), Manufacture of non-metallic mineral products (32), Basic metal and alloy

industries (33), Manufacture of metal products and parts except machinery and transport equipment (34), Manufacture of machinery, machine tools and parts, except electrical machinery (35), Manufacture of electrical machinery, apparatus, applicances and supplies and parts (36) and Manufacture of transport equipment (37). Data on 15 variables pertaining to the above seventeen industries provide the data-base for the inter-industry cross-section anaylsis in this paper. Table 1 gives the coefficient of variation (CV) in respect of each of the variable included in the anaylsis.

Table 1

Coefficient of Variation of the Selected Variables

Variable	Arithmetic mean	Standard Deviation	Coefficient of Variation (%)
Total output (0) Rs. crores	2093	1792	85.62
Gross value added (V) Rs crores	465	355	75.19
Fixed capital (FC) Rs. crores	628	760	121.02
Productive capital (PC) Rs. crores	1011	1081	106.92
Employee mandays (EM) in lakhs	978	753	76.99
Number of workers (L) in '000	362	315	87.02
Materials consumed (R) Rs. Crores	1292	1226	94.67
Capital Intensity-1 (FC/L) Rs.	24180	25229	104.34
Capital intensity-2 (PC/L)	39571	35798	90.47
Other than workers / Workers Ratio (M)	0.29	0.11	37.93
Labour productivity (V/L) Rs.	18178	11708	64.41
Employee productivity (V/E) Rs.	14028	7778	55.44
Wage Rate (W) Rs.	4650	1630	35.05
Salary Rate (WS) Rs.	10880	3587	32.97

It can be seen from the table that the (CV) ranges from 32.97% in respect of employee salary rate to 410.58% in respect of the number of workers in different industries. High inter-industry variation is found in respect of Fixed capital (121.02%) Productive capital (106.92%) Capital per worker (104.34%) and materials consumed (94.67%). The inter-industry variation in respect of the selected variables is high enough to warrant regression analysis to disclose inter-relationships between productivity and other variables.

Productivity and Capital Intensity

Linear as well as log-linear (linear in logarithms) equations are fitted to the inter-industry cross-section data. One familiar hypotheses in the area of productivity and its determinants is that industries with higher capital intensity (fixed capital per worker productive capital per worker) also happen to be industries with high labour productivity (1). In other words, industries with above average capital intensity also enjoy above average labour productivity. The following regression results based on data for 17 industries support the above hypothesis.

Linear regression results

1. $V/L = 6825 + \underset{(9.04)^*}{0.30\ PC/L}$ $\quad R = 0.92\ \bar{R}^2 = 0.83$
2. $V/L = 8968 + \underset{(6.80)^*}{0.40\ FC/L}$ $\quad R = 0.87\ \bar{R}^2 = 0.74$
3. $V/E = 7531 + \underset{(6.89)^*}{0.27\ FC/L}$ $\quad R = 0.87\ \bar{R}^2 = 0.74$
4. $V/E = 61.25 + \underset{}{0.20\ PC/L}$ $\quad R = 0.91\ \bar{R}^2 = 0.82$

Log-linear regression results

5. $V/L = 3.82 + \underset{(10.14)^*}{0.58\ PC/L}$ $\quad R = 0.8642$
6. $V/L = 4.20 + \underset{(10.09)^*}{0.0.57\ FC/L}$ $\quad \bar{R}^2 = 0.8627$
7. $V/E = 4.64 + \underset{(9.54)^*}{0.50\ FC/L}$ $\quad \bar{R}^2 = 0.84.89$
8. $V/E = 4.36 + \underset{(8.85)^*}{0.50\ PC/L}$ $\quad \bar{R}^2 = 0.8286$

In the above equations the * indicates significance at 1% level of significance. The regression coefficients have appropriate signs and are satistically significant. The inter-industry differences in labour productivity are explainable in terms of inter-industry differences in respect of capital intensity. The high $\bar{R}^2$ values show that the major portion of the variations in labour and employee productivity are explained by the inter-industry differences in respect of capital intensity. For example, eg. 1 says that 83% of variation in respect of labour productivity is explainable in terms of the capital intensity differences. The log linear equations have uniformly high $\bar{R}^2$ than linear equations indicating that they prove to be better than the linear equations. All the equations together support the hypothesis that industries with above average capital intensity achieve above average levels of labour productivity.

Productivity and managerial resources

Harbison introduced and elaborated the concept of managerial resources in the following manner :

"I shall use the term organisation as a shorthand expression for the integrated aggregation of those persons who are primarily involved in managing risk and uncertainity-bearing, planning and innovation, coordination, administration and control, and routine supervision of an enterprise, I shall refer to the persons who perform these functions as managerial resources. The other people employed in the enterprise, who do not perform these functions, will be referred to as labour resources". (pp. 365-366).

In a latter work (jointly with Myers) Harbison includes the following personnel in the managerial resources or the 'Managerial hierarchy' : (3)

1. Promoters, top administrative officers and directors who may be owners, part-owners or simply hired professionals.

2. Junior executives, administrators and other members of the middle management group.

3. Staff specialists, technologists and experts such as scientists, engineers, lawyers and personnel and Labour relations officers.

4. First line supervisors.

To apply the concept in an empirical study based on the secondary data (data available in the ASI), the ratio of 'persons other than workers' to 'workers' may be used as a proxy for entrepreneurial organisation. The category truly reflects the inter-industry differences in managerial resources provided the proportions of employees who do not perform the managerial functions is the same or nearly so in different industries.

Following the organisational view of enterpreneurship and managerial resources, Harbison states a few tentative hypotheses on the basis of his experience over two years with approximately 75 enterprises in England, France, Germany, Italy, Belgium, Holland, Egypt, Saudi Arabia, Peru and the United States. We state the propositions below.

1. Industries requiring large capital investment appear to require a correspondingly large capital investment in organisation. Or put in a different way, large expenditures for equipment and machinery are likely to be quite unproductive unless there is a corresponding investment in organisation. ("Entrepreneurship as a Factor in Economic Development", pp. 368-369).

2. Organisation is probably the principal factor determining the productivity of labour, assuming that capital and natural resources are constant (Ibid, p. 371).

From this proposition Harbison draws an inference related to less developed countries."...development of high labour productivity in a primitive society may (...) require a much higher investment in organisation than in countries with a long industrial tradition. (Ibid, p. 372).

3. ".....because of non-economic factors (managerial persons may be guided in their decision making by considerations other than profits such as power, social prestige, ability to help friends and relatives which the success brings) which determine in part the behaviour of human beings as managerial resources, all organisations are probably 'inefficient' in affecting the optimum combination of economic resources which is theoretically possible". (Ibid, p. 379).

We estimated regression equations to throw light

on the first two hypotheses of Harbison. We used as a proxy of managerial resources the ratio between other than workers and workers denoting it by M. The following are the regression results.

Linear regression results

1. $V/L = -5385 + 83452.88M \quad R=0.8012 \quad \bar{R}^2 = 0.6180$
   $(5.19)^*$

2. $V/E = -1189 + 52687.41M \quad R=0.7614 \quad \bar{R}^2 = 0.5518$
   $(4.55)^*$

Log linear regression results

3. $V/L = 11.15 + 1.1232\ M \quad \bar{R}^2 = 0.6497$
   $(5.54)^*$

4. $V/E = 10.64 + 0.9269\ M \quad \bar{R}^2 = 0.5631$
   $(4.67)^*$

As in the case of capital intensity, in the case of managerial resources also we find high explanatory power. The coefficient of M in all the four equations are statistically significant and the coefficient of determination $\bar{R}^2$ is around. 55 in the case of regressions with employee productivity as the dependent variable and is around 0.60 in the case of labour productivity as the dependent variable. As in the earlier set of equation explaining the variation in terms of capital intensity, the equations of loglinear form have more explanatory power than the linear equations. Managerial resources as well as capital intensity thus are found to be important determinants of inter-industry productivity differentials. Now we present the results of the multiple regression analysis.

Linear regression results

1. $V/L = -267 + 0.28\ FC/L + 4232M \quad \bar{R}^2 = 0.8490$
   $(4.38)^* \qquad (3.0)^*$

2. $V/E = 4285 + 0.17\ PC/L + 984M \quad \bar{R} = 0.8176$
   $(4.78) \qquad (0.85)$

3. $V/L = 485 + 0.23PC/L + 22084M + 0.59W \quad \bar{R} = 0.8396$
   $(4.13)^* \quad (1.33) \quad (0.63)$

4. $V/E = -571 + 0.14PC/L + 10989M$
   $(3.93)^* \quad (1.06) \quad + 0.5360WE \quad \bar{R}^2 = 0.8548$
   $(2.14)^{**}$

5. $V/L = 5.41 + 0.48\ FC/L + 0.25M \quad \bar{R}^2 = 0.8663$
   $(5.03)^* \qquad (1.18)$

6. $V/E = 3.17 + 0.58\ PC/L - 0.22M \quad \bar{R}^2 = 0.8249$
   $(4.84)^* \qquad (0.83)$

7. $V/L = 1.81 + 0.43\ PC/L + 0.10M$
   $(4.16)^* \qquad (0.48)$
   $+ 0.44W \quad \bar{R}^2 = 0.9217$
   $(3.60)^*$

8. $V/E = 1.41 + 0.32\ PC/L + 0.15M$
   $(3.50)^* \qquad (0.84)$
   $+ 0.53WE \quad \bar{R}^2 = 0.9331$
   $(4.86)^*$

The above multiple regression equations confirm the earlier results about the determinants of the inter-industry differences in respect of labour and employee productivity. Except the managerial resource variable (M) all other variables have regression coefficients with appropriate signs and they are all statistically significant either at 1% or 5% (** stand for 5% level of significance) level of significance. The explanatory power of the equations is found to be higher than when only one independent variable is included. One interesting point which emerges from the multiple regression equations above is that wage and salary rates impinge positively on productivity. From the estimated loglinear equations it can be seen that the elasticity of labour productivity with respect to the wage rate is .44 (eq. 7 above) and the elasticity of employee productivity with respect to the salary rate is 0.53 (eq. 8 above). The coefficients of determination tell us that more than 90% of the variation in labour and employee productivity can be explained by the variation 1. capital intensity, 2 managerial resources and 3. wage/salary rate. One rather exceptional point to be noted is that while managerial resource has positive and significant coefficient in simple linear and log-linear regression equations, in multiple regression equations it has not come out with a statistically significant coefficients, In eq. (6) its sign has come out to be inappropriately negative.

On the whole the regression results show the following as the determinants of the inter-industry difference in productivity 1. Fixed capital per worker,

2 productive (or fixed plus working) capital per worker, 3. Managerial resources, and 4. Wage/salary rate.

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2. Federick Harbison, "Enterpreneurial Organisation as a Factor in Economic Development, "*Quarterly Journal of Economics*, Vol LXX No. 3 August 1956, pp. 364-379. Galbraith uses the term "Technostructure" to describe organisation. See his The New Industrial State (London; Oxford and IBH Publishing Campany, 1967)
3. F. Harbison and C.A. Myers, *Management in the Industrial* World, (New York: McGraw-Hill Book Company, Inc. 1959).

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Total Factor Productivity in Basic Metal Industries

DR. N.C. GUPTA

The present paper analyses the contribution of total factor productivity growth to output growth in related industries. The paper reports an interesting finding, that there is a divergence between total factor productivity growth emerging from total factor productivity indices and the coefficient of t in the production functions. It, therefore, leaves scope for further research work to test the performance of the two methods in different industries.

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Studies relating to productivity growth in manufacturing industries reveal different trends. Some of the studies[1] report a significantly rising trend whereas others[2] show that the contribution of total factor productivity to output growth has been virtually nil. The present paper is devoted to the analysis of productivity growth in Non-Ferrous Basic Metals Industries. This group of industries comprises of primary non-ferrous metals and non-ferrous semis and alloys. Primary non-ferrous metals like aluminium, copper, lead and zinc have important forward linkages.

A detailed review of the literature on the measurement of productivity growth is not being attempted here in view of the availability of comprehensive and exhaustive survey articles[3]. Among the partial productivity ratios labour productivity and capital productivity are important. We consider Kendrick and Solow Indices for measuring total factor productivity.[4] We have experimented with the basic SMAC relationship and some of its extensions[5]. After testing for the elasti-

1. Hashim and Dadi (1973), Narasimham and Fabrycy (1974), Oommen and Evenson (1977), and Goldar (1981).
2. Raj Krishna and S.S. Mehta (1968) and Banerji (1975).
3. Nadiri (1970), Kennedy and Thirlwall (1972), and Goldar (1981).
4. For details about construction of variables and indices, see N.C. Gupta (1981).
5. Banerji (1975) and Griliches (1967).

city of substitution, we estimate the following general form of the Cobb-Douglas production function :

$$\log V_{it} = \alpha_o + \partial_i + \gamma_t + \alpha \log E_{it} + \beta \log K_{it} + U_{it}$$

where,

V represents gross value added,

K capital input, and

E labour input in worker-equivalents.

The subscript i refers to region and t to time.

A time series of cross section data over regions has been used. The ∂'s and T's are the coefficients of the region and time dummy variables, and U_{it} refers to the random disturbances. It is assumed that all the regions have the same coefficients α and β, and also that they remain constant over time. However, the use of the dummy variables for regions allows each region to have its own intercept. The same is true of years. This should reduce the mis-specification consequent on assuming the same slopes for all regions and to the extent the disturbance term in the production function is net of the region and year effects, the function is relatively well specified and hence the simultaneity bias in the ordinary least squares estimates is perhaps reduced. Allowing for different intercepts improves the fit, as well. We have multiplied the per establishment variables be $\sqrt{N_i}$ to correct for heteroscadasticity, where N_i is the number of establishments.

2: Empirical Results

2.1 Partial Productivity Indices

In this section, we present the empirical results relating to (i) Partial Productivity Indices, and (ii) Total Factor Productivity Indices. These results are based on aggregate time series data for the NFBM industries for the country as a whole for the periods 1948-58 and 1960-70 taken from C.M.I. and A.S.I respectively.

1948-58 : During this period labour productivity increases at an annual average rate of 5.9 per cent (col. 2, Table 1). On the other hand capital productivity shows a decline of 1.3 per cent per annum (col. 3) and when this measure is corrected for capacity utilization, it shows an increase of 1.7 per cent per annum (col. 4).

Table 1

Average Annual Rates of Growth (Per cent) of the Indices of Labour Productivity (V/L), Capital Productivity (V/K and V/KU), Capital-Labour Ratio (K/L), Real Wage Rate (w), Percentage Share of Labour in Value Added (W/L) in NFBM Industries : 1948-70 *

Year	V/L	V/K	V/KU	K/L (Rs.)	W (Rs.)	W/L (Per cent)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Aluminium, Copper and Brass : 1948-58	5.9	—1.3	1.7	7.2	5.3	—0.6
B. NFBM Industries 1960-70	1.2	—5.3	—2.1	6.5	—0.2	—1.3

* Data for 1959 are not used.

Source : CMI 1948—58, ASI 1960-70.

Thus the variation in capacity utilisation accounts for the observed decline of the productivity of capital in existence. The indices of labour and capital productivities display considerable short-run fluctuations.

1960-70 : The annual average rate of increase of labour productivity during this period is of the order of 1.2 per cent. The productivity of capital shows a substantial decline of about 5.3 per cent, and the fall is pronounced after 1966. After correction for capacity utilisation the rate of annual decrease comes to 2.1 per cent. Thus, the performance of the industry in respect of productivity during 1960-70 is worse, compared to the earlier period.

The predominant influence behind marginal increase in labour productivity seems to be capital intensity. Capital per employee (K/L) has doubled over the period 1960-70, from about Rs. 17,000 in 1960 to about Rs. 34,000 by 1970. Capital substitution thus turns out to be the dominant feature of growth during 1960-70, in spite of the real wage rate showing an annual average decline. The share of labour in value added ranges between 30 to 38 per cent during 1960-62 and 1969-70, whereas it has been much less i.e. 22 to 27 per cent during the rest of the period.

The average annual rate of growth in the capital/labour ratio (K/L) has been of the order of 6.5 per cent during 1960-70. The increase in capital intensity that one observes in the case of NFBM industries during 1960-70, may be explained in terms of easy and cheap availability of funds. Aluminium forms the most important component in NFBM industries. The large aluminium firms—Hindalco, Indal and Malco—could arrange funds at nominal rates of interest, say 5 to 6 per cent, through foreign financial institutions. The foreign collaborators participating in Indian firms who were interested in maximising profits helped their Indian counterparts[6] in this regard.

The fall in capital productivity in NFBM industries during 1960-70, with slight fluctuations for 1963, may be attributed to decline in capacity utilisation[7]. The index of capacity utilisation for NFBM industries shows a general decline. The decline is much sharper in the case of copper and brass. Even in the case of aluminium, although there is no clear trend, capacity utilization does show a mild decline after 1965. The coefficient of correlation between the index of capital productivity worked out in col. 3, Table 1, and the index of capacity utilisation[8] works out to 0.51.

2.2 Total Factor Productivity Indices

The total factor productivity indices for NFBM industries are presented in Table 2. There is a parallel movement in the Kendrick and Solow Indices in both the C.M.I. and the A.S.I. periods.

1948-58 : We first discuss the indices relating to C.M.I. The Kendrick and the Solow Indices do not show a systematic rising trend over the period 1948-58 These are appreciably below 100 for 1952, 1953 and 1956. The average annual rates of growth of the Kendrick and the Solow Indices range between .7 and .8 per cent only.

6. Indal could arrange funds by issue of debenture stock not only in India but also abroad. Hindalco has been arranging funds mostly from IDA and other US financial institutions. Malco, however, has been greatly helped by the Indian financial institutions like I.F.C.
7. N.C. Gupta (1981), Chapter II, Table 2.7, p. 34.
8. ibid.

Table 2

Total Factor Productivity : Kendrick and Solow Indices : 1948-70*

Year	Kendrick Index $I_{(t)}$	Solow Index $A_{(t)}$
1	2	3
	A. Aluminium, Copper and Brass: 1948-58	
1948	100.0	100.0
1949	87.4	86.3
1950	102.9	100.6
1951	94.6	92.5
1952	65.7	63.1
1953	59.2	58.2
1954	88.8	87.4
1955	109.9	108.6
1956	83.3	81.8
1957	101.7	100.8
1958	104.1	103.9
Average annual rate of growth (per cent)	0.7	0.8
	B. NFBM Industries : 1960-70	
1960	100.0	100.0
1961	103.8	104.1
1962	104.3	104.3
1963	128.8	127.9
1964	125.6	124.3
1965	113.1	111·2
1966	93.6	85.8
1967	93.8	85.9
1968	67.9	63.9
1969	89.9	85.3
1970	84.0	79.5
Average annual rate of growth (per cent)	—3.3	—4.2

*Data for 1959 are not used.

1960-70 : In the early 1960s total factor productivity is above the level in 1960, appreciably so only for 1963 and 1964 (Table 2). In the post-1965 period, total factor productivity is far below the level in 1960. It is particularly low in 1968, Kendrick and Solow Indices being 68 and 64, respectively. In other years, the Kendrick Index is in the range of 84 and 94, whiie the Solow Index is in the range of 80 to 86. The average annual rate of decline in total factor productivity (Kendrick and Solow Indices) ranges between 3 to 4 per cent.

Total factor productivity in NFBM industries shows a decline during 1960-70 because of the retarded growth in other non-ferrous metals (basic) and non-ferrous semis components of NFBM rather than aluminium. Capital formation in industries like copper, lead and zinc had been very slow. Even the capacity established was not fully utilized for want of ore, technical skill and experience. Non-ferrous semis industries suffered on two counts. In the wake of Indo-Pak War, with the promulgation of the Scarce Industrial Materials Control Order 1965, these firms were not allowed to use their own stocks of primary non-ferrous metals which adversely affected their production. During 1967 and 1968, these firms suffered because of lack of orders from bulk purchasers like Railways and Directorate General of Supplies and Disposals.

The decline in total factor productivity may also be attributed to slackness on the part of management in aluminium industry because they have been in a position to get higher profits[9] in comparison to the corporate sector during 1960-70 except for 1960, 1961 and 1963, and other non-ferrous metals (basic) from 1966 onwards. Productivity of persons other than workers (which include managerial and supervisory staff) which may represent efficiency or slackness on the part of management shows a decline from 1964 (1960 = 100) onwards.[10] The index for 1968 i.e. 75 is appreciably below the level of 1960. The absence of statutory price control on aluminium till 1970 and its oliogpolistic structure seem to have helped the industry earn higher profits despite and apparent fall in total factor productivity.

Empirical Results : Production Function Estimates Elasticity Substitution

The estimates of the production function parameters presented in this section are based on pooled time series data for four regions viz. West Bengal, Madras and the Rest of India.

We have tried several variants of the side relation of the Constant Elasticity of Substitution (CES) production function. The estimates are reported in Table 3.

The partial adjustment model (see col. 4) yields quite plausible estimates. The estimate of $\hat{\sigma}$ is reasonable and the coefficient of log $(V/L)_{t-1}$ is statistically significant and bears the right sign. It yields an estimate of $\hat{\sigma} = 1.08$. This is the preferred regression in terms of DW[11] and $\bar{R}^2$. It may be noted that the regressions in cols. 2, 3, 6 and 8 also yield estimate of the elasticity of substitution not significantly different from unity. *A priori*, we cannot decide as to which one is the correct model. An estimate of $\hat{\sigma}$ not significantly different from one is provided by many of the models tested.

Cobb-Douglas Production Function

Having found evidence to show that the elasticity of substitution is not significantly different from unity, we proceed to discuss the results of the estimation of Cobb-Douglas production function. The results are obtained for C.M.I. and A.S.I. combined.[12] These results are analysed below.

The unrestricted Cobb-Douglas production function

9. N.C. Gupta (1981), Table 28, Chapter II, p. 36.
10. Index No. for 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970.
153 132 117 117 118 75 109 111.
11. The use of the D.W. statistic in a model with lagged dependent variable among explanatory variables as in the case of the equation in col. 4 is not appropriate. Durbin proposes a test for serial correlation in the error terms in the autoregressive models. The h-statistic proposed by him is appropriate in such a case. See Durbin (1970), p. 410.
12. For results relating to 1948-58 and 1960-70, see N.C. Gupta, (1981).

Table 3

Least Squares Estimates of the Elasticity of Substitution Between K and L in NFBM Industries 1949-70 : Pooling of Region-Level Observations**

Dependent Variable : $Log\ (V/L)_t$ No. of Observations : 80

Independent Variables	SMAC Method	SMAC with time	Partial Adjustment model	Serial Correlation model	SMAC with labour	SMAC with Series Dummies (A.S.I.)	SMAC with Region Dummies
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log W_t	0.950*	0.983*	0.288*	0.250	1.163*	0.640*	1.142*
	(0.161)	(0.154)	(0.133)	(0.208)	(0.201)	(0.139)	(0.217)
log W_{t-1}				0.054			
				(0.228)			
log $(V/L)_{t-1}$			0.734*	0.726*			
			(0.079)	(0.087)			
log L_t					−0.128		
					(0.738)		
Time (t)		0.007*					
		(0 002)					
Dummy (A.S.I.)						0.609*	
						(0.094)	
Dummy (Bombay)							−0.159
							(0.160)
Dummy (Madras)							0.321
							(0.199)
Dummy (R.O.I.)							0.158
							(0.149)
$\bar{R}^2$	0.298	0.368	0.662	0.657	0.316	0.539	0.357
DW	0.913	1.033	2.367	2.352	1.007	1.009	1.099

**Data for 1959 have not been used.
Standard errors are given in brackets.
*Significant at 5 per cent level.

yields positive and significant estimates of the coefficients of capital and labour (total employees—Regression 1, and worker equivalents—Regression 2) (Table 4). The returns to scale estimate is not significantly different from one in both the models. In Regression 3 capital is adjusted for capacity utilisation, whereas in Regression 4, capacity utilisation is taken as a separate explanatory variable. The results for Regression 3 are similar to those for Regressions 1 and 2. Capacity utilisation is also significant in Regression 4. Regressions 6 and 7 employ series dummy and region dummies, respectively. Series dummy for A.S.I. comes out to be significant in Regression 6. Possibly this result could be attributed to differences in coverage between the two data sources. Use of series dummy results in lowering the magnitude of capital elasticity and increasing labour elasticity in comparison to results in Regression 2.

The region dummies in Regression 7 are non-

Table 4

Least Squares Estimates of the Cobb-Douglas Production Function for NFBM Industries: Pooling of Region-Level Observations 1948-70**

Dependent Variable : *log V* No. of Observations : *88*

Regn. No.	Coefficients of Independent Variables												Return to Scale	R^2
	log K	log KU	log L_W	log L_{WN}	log L	log E	log U	t	Dummy ASI	Dummy Bombay	Dummy Madras	Dummy ROI		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1.	0.474* (0.036)				0.579* (0.081)								1.053 (0.058)	0.91
2.	0.441* (0.040)					0.619* (0.087)							1.060 (0.059)	0.91
3.		0.484* (0.054)				0.607* (0.105)							1.091 (0.066)	0.89
4.	0.393* (0.044)					0.751* (0.101)	0.236* (0.098)						1.44	0.92
5.	0.358* (0.053)					0.746* (0.101)		0.004* (0.002)					1.104	0.92
6.	0.371* (0.050)					0.699* (0.092)			0.206* (0.093)				1.070	0.92
7.	0.423* (0.047)					0.698* (0.148)				0.029 (0.114)	0.128 (0.192)	0.094 (0.106)	1.121	0.91
8.	0.508* (0.033)		0.548* (0.076)										1.057 (0 058)	0.91
9.	0.529* (0.054)		0.596* (0.126)	−0·065 (0.135)									1.125	0.91
10.	0.404* (0.066)		0.709* (0.126)	0.013 (0.131)			0.006* (0.002)						1.113	0.92

*Significant at 5 per cent level.

**Data for 1959 have not been used.

Standard errors are given in brackets.

significant. This seems to suggest that firms in different regions enjoy the same efficiency as West Bengal which has been taken as the norm.

In Regression 8, we take number of workers as measure of labour, whereas in Regression 9, we distinguish between workers and 'persons other than workers'. The coefficient of L_{NW} is negative but non-significant in Regression 9, whereas it is positive and non-significant in Regression 10.

Regression 5 and 10, including time variable, indicate that total factor productivity increased at an average rate of .4 and .6 per cent over the period as a whole and the increase turns out to be statistically significant.

Results relating to different regressions discussed above suggest robustness of the parameter estimates. The adjustment for quality of labour, capacity utilisation, the introduction of series dummy, region dummies and time variable confirm the stability of capital and labour coefficients. The finding of constant returns to scale remains unaffected. This is in broad agreement with the earlier estimates on returns to scale in respect

of NFBM industries using C-D production function by Narasimham and Fabrycy[13] and Yeh[14], and using Bayesian and Maximum Likelihood techniques by Sankar.[15] Series dummy in Regression 6 has a positive and significant coefficient. This could be attributed to differences in data coverage.

The divergence in the results relating to productivity growth emerging from use of two different formulations —total factor productivity indices and production function estimates may be due to differences in assumptions of the two methods. Total factor productivity indices assume that the marginal productivities of capital and labour are equal to their respective rewards in terms of interest rate and wage rate, at least in the base year. The underlying assumption of the C-D production function estimation is that the prices of products and factors are either known with certainty or are statistically independent of the production function disturbance.[16] The coefficients of the C-D production function may be subject to the simultaneity bias.

13. Returns to scale = 0.99 (Period : 1949-58, Source: CMI) Narasimham and Fabrycy (1974), pp. 230-41.

14.

Returns to Scale			Period	Source
Model I	Model II	Model III		
1.4*	1.21*	1.06*	1953-58	CMI
0.99**	0.99**	1.00**		

*Significantly different from unity.

**With correction for quality of workers, represented by wage rate included as an additional variable to the specifications.

Yeh (1966), pp. 275-91.

15.

Bayesian Estimate		M.L. Estimate
Mean of λ	Model value for λ	Estimate of λ
1.060	1.050	1.053

Period	Source
1953-58	CMI

Sankar, (1970).

16. Zellner, Kmenta and Dreze (1966).

Comparison of Results on Total Factor Productivity[17]

We compare the results relating to the coefficient of t variable in C-D and C.E.S. production functions of earlier studies with those of the present work (Table 5). Sankar's estimate of 'g' worked out with the help of Bayesian method signifies technical progress (loosely termed) but the magnitude is very small. The coefficient of time variable using both the C.E.S and C-D production functions in Venktaswami's study for the period 1948-67 comes out to be positive. In the present study the magnitude of the t coefficent using C.E.S. production function is nearly double the one using C-D production function and is both positive and significant in the C.E.S. case. The present results are in broad agreement with those of Venkataswami and Sankar. However, we cannot conclude from these results that there had been a sustained growth in total factor productivity in NFBM industries during the period 1948-70 as a whole.

Summary and Conclusions

Total factor productivity measured by Kendrick and Solow indices shows an average annual rate of growth between .7 and .8 per cent during 1948-58. The indices worked out for the period 1960-70 show an average rate of decline between 3 and 4 per cent. The decline in total factor productivity may be seen in the context of general deceleration in Indian manufacturing in 1965.[18] But, here it must be mentioned that there was no dearth of demand in respect of the primary non-ferrous metals – aluminium, copper, lead and zinc. The demand constraint, however, did relate to the production of non-ferrous semis manufactures because of the curtailment of orders by the concerned bulk users like Railways, Posts and Telegraphs and Directorate General of Supplies and Disposals during 1967 and 1968. Capital formation in aluminium was faster than

17. The variable 'T', sometimes loosely called 'technology' really embraces all the forces that influence output in addition to changes in the physical volume of the tangible factor inputs. It is less misleading to refer to T as the "productive efficiency" of the tangible factors, or "total (tangible) factor productivity".
See Kendrick (1977), p. 12.

18. Nayyar (1978), pp. 1265-78.

Table 5

Estimates of Total Factor Productivity (TFP) Parameter in respect of NFBM Industries—Comparison of earlier studies with the present study

Author	Period and Source	Method	Time Series Cross Section	Estimates of TFP	
(1)	(2)	(3)	(4)	(5)	
Sankar	1953-58 (CMI)	Bayesian	Time Series	Estimates of 'g'	.009
Venkataswami	1948-67 (CMI and ASI)	CES	Time Series	Coefficient of 't'	.218
		C-D	Time Series	,,	.048
Present Study	1948-70 (CMI and ASI)	C-D	Pooling of time series of cross sections over regions.	Coefficient of 't'	.003 (.002)
		CES	,,	,,	.007* (.002)

Standard errors are given in brackets.
*Significant at 5 per cent level.

in copper, lead and zinc, the other basic non-ferrous metals. These industries could not develop as fast as aluminium because of shortage of ore, technical expertise and experience. Fall in productivity of 'persons other than workers' may be cited as internal evidence towards slackness on the part of management. This happened at a time when profitability in aluminium had been higher as against the corporate sector. The fall in total factor productivity and high profitability in aluminium[19] may be due to absence of statutory price control on aluminium till 1970 and its oligopolistic structure.

The paper reports an interesting finding, that is, the divergence between total factor productivity growth emerging from total factor productivity indices and the coefficient of t in the production functions. It, therefore, leaves scope for further research work to test the performance of the two methods in different industries. Micro-study on total factor productivity at the firm-level remains so far a completely neglected field. Efforts in this direction are very much needed.

19. Since aluminium forms a sizeable component.

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Regional Productivity Variations

K. C. SINGHAL

The present research paper attempts at studying the relative importance of the region and structure effects in determining the productivity differentials. It has been observed that the region effect is more important than the structure effect.

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Productivity is one of the important determinants of economic growth. More so, in the underdeveloped countries where the rate of capital formation is low. The productivity differentials over the globe are quite high between the developed and underdeveloped countries. The regional variations in productivity are significant not only among the countries but even among the regions of a country. In India, too, the productivity differentials among the various regions could be easily felt.

Productivity in its broadest sense may be defined as output produced by a worker per unit of time. This time can be a year, a month, a day, or an hour. Similarly, output of a concern can be defined as the total sale value of the products for final sales or the total value added in manufacture. Productivity can thus be defined as value added in manufacture per man-hour.

Many studies have attempted an analysis of industrial productivity at the All India Level. Beri (1962) shows that there is a positive association between labour productivity and capital intensity as well as economies of scale. Reddy and Rao (1962) also find positive association of capital intensity but constant returns to scale. Banerji (1975) explains inter-state disparities for value added in terms of capital intensity Mehta (1980) concludes that there was no significant association between labour productivity and capital intensity. Very few studies have been taken at the regional level. Rao (1976) shows that regional disparities decreased or remained more or less constant

over time in most of the industries and labour productivity increased mainly because of increase in capital intensity. Sailaja (1981) concludes that inter-state disparities for total manufacturing sector show no clear tendency to increase or decrease. But very few studies have looked into the relative importance of industrial structure and local factors in the regional productivity variations. The present study is an attempt in this direction.

The objective of the present paper is to study the regional productivity differentials and the factors contributing to such disparities. In this study productivity means value added in manufacture per man hour.

Regional productivity itself is a function of two sets of variables—the 'regional industrial structure' and the other is the 'local' factors.

The variations in productivity arising out of the regional variation in 'industrial structure' could also be referred to as 'technological' variations. These may include variations in overall capital-intensity of production in these regions which in turn may be a reflection of variations in the skill-mix employed in the industrial set up of these regions (Kerr, 1963).

The 'local factors' that affect the levels of regional productivity and thus determine the inter-regional variations in them are : (i) educational composition of the population in region, (ii) availability, quality and utilisation of other resources in a region (iii) the climatic and the overall working conditions, (iv) the institutional factors like the social taboos against certain categories of work etc. and so on.

The study aims at analysis of the regional productivity differentials in all the 21 major industry groups in 1975-76 and to find which factor is more important, that is whether it is the structure or the 'local factors'.

Data Base : The study makes use of the cross sectional data for the year 1975-76. The only source of data is the Annual Survey of Industries (ASI), Census Sector. The data on the two related variables i.e. the value added in manufacture and the number of man-hours worked has been compiled from the ASI.

The biggest difficulty has been that ASI gives data only at the three digit level for the states where as the study related to only 21 major industry groups at the two digit level. The data has been first collected at the three digit level for both the variables and then aggregated to the two digit level industry group. In addition to the 21 major industry group another miscellaneous industry group has been created. All industries where the value added, man-hours and other variables are insignificant have been grouped into this category. Table I gives the number and name of two digit level industries.

Methodology : The overall regional differentials have been broken up into their 'structural' and 'regional' components. The methodology adopted for this purpose has been taken from the survey article by Brown (1969). The exercise involves eliminating effect of 'local factors' affecting the productivity in one case and the effect of 'industrial structure' in the other. Before going into the method of computing 'structure' and 'region' effects, we would like to define two concepts—the concept of 'structure constant' productivity and 'rate constant' productivity.

Structure Constant Productivity

The 'structure constant' productivity for a region can be defined as the productivity level that would prevail in a region if the industrial structure of the region confirmed to the national industrial structure. This effect excludes the effect of industrial structure on the regional productivity and reflects the amount of inter-regional productivity variations emanating from the operation of the 'local factors'.

If h_{ij} represents the number of man-hours worked in industry 'i' and region 'j',

h_j represents the number of man-hours worked in all the industries in region 'j'

$$\text{i.e., } h_j = \sum_{i=1}^{n} h_{ij}$$

h_i represents the number of man-hours worked in all the regions in industry 'i'

$$\text{i.e., } h_i = \sum_{j=1}^{n} h_{ij}$$

Table I

21 Major Industrial Groups-ASI (Census Sector) 1975-76

Major Group No.	*Name of the Industry*
20-21	Manufacture of food products
22	Beverages, Tobacco & Tobacco Products
23	Cotton Textiles
24	Wool, Silk and Synthetic Fibre Textiles
25	Jute, Hemp and Mesta textiles
26	Textiles products (including wearing Apparel other than footwear)
27	Wood & wood products, furnitures & fixtures
28	Paper & paper products and printing, publishing and allied Industries
29	Leather & Leather & Fur Products (except repair)
30	Rubber, Plastic, Petroleum & Coal Products
31	Chemicals & Chemical Products (except products of Petroleum & Coal)
32	Non-Metallic Mineral Products
33	Basic Metal & Alloys Industries
34	Manufacture of Metal Products and Parts except Machinery and Transport Equipment
35	Machinery, Machine Tools & Parts, Except Electrical Machinery
36	Electrical Machinery Apparatus & Appliances and Supplies and Parts
37	Transport Equipment and Parts
38	Other Manufacturing Industries
40	Electricity
41	Gas and Steam
42	Water Works and Supply
74	Storage & Ware Housing
97	Repair Services
99	Miscellaneous

H represents the number of man-hours worked in all the industries in all the regions

$$\text{i.e. } H=\sum_{i=I}^{n} h_i = \sum_{j=I}^{n} h_j$$

and p_{ij} regional productivity in industry 'i' and region 'j'

then, the 'structure constant' productivity for region 'j' could be defined mathematically as :

$$P_j\ (s)=\frac{\sum_{i=I}^{n} h_i\ p_{ij}}{H}$$

where P_j (s) is the 'structure constant' productivity for region 'j'.

The condition for 'structure constant' productivity is :

$$\frac{h_{ij}}{h_j} = \frac{h_i}{H}$$

'Rate Constant' Productivity

For calculating the 'rate constant' productivity, we hold the regional industrial productivity levels (p_{ij}'s) constant at the national industrial productivity levels. If the national productivity levels are represented by 'p_i' for all industries 1 to n, the condition for the calculation of the 'rate constant' productivity becomes :

$$P_{ij} = P_i$$

this eliminates the effect of 'local factors' determining productivity levels.

Thus 'rate constant' productivity level for a region may be defined as the regional productivity level that would have prevailed in the region, if the industries situated in a region had maintained national productivity level. Mathematically it could be defined as :

$$p_j\ (r)\ =\frac{\sum_{i=I}^{n} h_{ij}\ p_i}{h_i}$$

where p_j (r) is the 'rate constant' productivity for region 'j'.

Our aim would be to see to what extent the industrial structure of a region and the other local factors determine total productivity effect, it being defined as the deviation of the average productivity of a region from the national average productivity.

This brings us to the description of the methodology employed in calculating the 'structure' and 'region' (or 'rate') effects which go into the formation of 'total effect'.

'Structure effect', S, could be defined mathematically:

$$S = p_j - p_j\,(s)$$

and the 'Region effect', R, is :

$$R = p_j - p_j\,(r)$$

where p_j, p_j (s) and p_j (r) are the average productivity level, ,structure constant', and 'rate constant' productivity for region 'j',

Besides, the above two effects, there is a third type of effect, the 'interaction effect', 'I', which is caused by the inter-relationship between the two types of effects. This effect can be worked out by multiplying the deviation of regional industrial structure from the national industrial structure by the deviation of average regional productivity from the average national productivity. Mathematically interaction effect, I, is :

$$I = p_j - p_j\,(r) - p_j\,(s) + P$$

where p_j, p_j (s) and p_j (r) are already defined and P is the average national productivity level.

'Total effect', T, is :

$$T = S + R - I = p_j - p_j(s) + P_j - p_j\,(r)$$
$$-(p_j - p_j(r) - p_j(s) + p) = p_j - p$$

Thus we find the 'total effect' is deviation of the average regional productivity from the average national productivity.

We have made use of the techniques suggested by Brown to decompose the deviation of regional productivity from the national productivity i.e. the total effect into structure effect, region and interaction effect.

First we have calculated the 'structure constant' and 'rate constant' productivity. The calculated figures for these two variables along with the 'structure' and 'region' effects calculated from them are given in table II. Column (3) gives the average productivity in various states. Column (4) and column (5) of the table give 'structure constant' and 'rate constant' productivities and column (6), (7) and (8) give the 'structure effect', 'region effect' and the 'interaction effect' as components of the total effect given in column (9).

The average All India productivity (P) is Rs.6.498 per man hour.

The average industrial productivity among states is highest in Punjab (Rs.11.056) followed by Maharashtra (Rs.9.385), Bihar (Rs.8.656) and Madhya Pradesh (Rs.8.288), the lowest being in Jammu & Kashmir. In J & K because of its physiography, the overall industrial development is very low, and then whatever the industries like wool and silk textiles, and non-metalic products, they have got very low productivity.

Maharashtra is a highly industrialised state and moreover the industries like machinery, machine tools and parts, chemicals and chemical products and machinery are highly productive. Punjab's position is better because of electricity where also the productivity is higher than the all India average productivity. If we look into structure constant productivity depicting the effect of local factors. The value of this variable is very low for Manipur (Rs.0.093), Meghalaya (Rs.0.347) and Jammu & Kashmir (Rs.0.869) and it is maximum for UP. (Rs.12.554).

Similarly rate constant productivity is lowest for Assam (Rs.5.524), Tripura (Rs.5.669) and Gujarat too (Rs.5.849) and maximum for Manipur (Rs.9.644), Meghalaya (Rs.9.644) and Jammu & Kashmir (Rs.8.548).

The picture regarding the importance of technical factors or local factors is better drawn by the structure effect and the region effect. We find that the structure is unfavourable to Gujarat, Uttar Pradesh, and West Bengal. This is because we find that in Uttar Pradesh where the structure is highly unfavourable (Rs.-6.438), the dominant industry is Sugar which has very low productivity. Similarly in West Bengal the dominant Jute industry is highly unproductive. The productivity for this industry for the country as a whole is Rs.2.928. Gujarat too has low productive textile industry.

It was most favourable to Assam and Meghalaya, followed by Bihar. Bihar has highly favourable

Table II

Components of Productivity and Productivity Effects—1975-76
(in Rs per man hour)

Sr. No.	States	Components P_j	(s) P_j	(r) P_j	S	R	I	I
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Andhra Pradesh	5.734	5.992	5.822	—0.258	—0.088	0.418	—0.764
2.	Assam	6.495	1.982	5.524	4.513	0.971	5.487	—0.003
3.	Bihar	8.656	5.082	7.889	3.574	0.757	2.173	2.158
4.	Gujarat	6.070	6.807	5.849	—0.737	0.221	—0.088	—0.428
5.	Haryana	7.579	5.029	7.556	2.550	0.023	1.492	1.081
6.	Himachal Pradesh	6.202	2.320	7.459	3.882	—1.257	2.921	—0.296
7.	J & K	1.081	0.869	8.548	0.212	—7.467	—1.838	—5.417
8.	Karnataka	6.965	6.531	6.696	0.434	0.296	0.236	0.467
9.	Kerala	3.894	3.735	6.212	0.159	—2.318	0.445	—2.604
10.	Madhya Pradesh	8-288	6.127	6.200	2.161	2.088	2.495	1.790
11.	Maharashtra	9.385	8.974	6.697	0.411	2.706	0.230	2.887
12.	Manipur	1.315	0.093	9.644	1.222	—8.329	—1.924	—5.183
13.	Meghalaya	4.920	0.347	9.644	4.573	—4.724	1.427	—1.578
14.	Orissa	5.074	3.038	7.858	2.036	—2.784	0.676	—1.424
15.	Punjab	11.056	9.500	6.774	1.556	4.282	1.280	4.558
16.	Rajasthan	6.479	4.927	6.094	1.822	0.385	2.226	—0.019
17.	Tamil Nadu	5.008	4.962	6.104	0.046	—1.096	0.440	—1.490
18.	Tripura	1.330	0.378	5.669	0.952	—4.330	1.781	—5.168
19.	U.P.	6.116	12.554	6.138	—6.438	—0.022	—6.078	—0.382
20.	West Bengal	4.824	5.121	6.189	—0.297	—1.365	0.012	—1.674
21.	Andaman & Nicobar Islands	2.801	0.493	7.397	2.308	—4.596	1.409	—3.697
22.	Chandigarh	7.866	1.562	8.092	6.303	—0.226	4.709	1.168
23.	Delhi	3.946	4.242	6.109	—0.296	—2.162	0.093	—2.552
24.	Goa, Daman & Diu	11.313	3.021	6.953	8.292	4.360	7.837	4.815
25.	Pondichery	4.498	1.030	4.420	3.195	0.078	5.273	—2.000

All India Productivity, P, is Rs. 6.498 per man-hour.

structure because of the various non-metalic and basic metal and alloys industries.

The 'region effect', (R), is most favourable to Punjab where it comes out to be Rs. 4.282, followed by Maharashtra (Rs. 2.282) and Madhya Pradesh (Rs. 2.088). It was unfavourable to Manipur (Rs. 8.329) and Jammu & Kashmir (Rs. 7.467).

Now let us identify states where both S & R are unfavourable. Out of the 20 states we find about half of the states have both the effects either favourable or

unfavourable. For rest of the states one effect is favourable, the other is unfavourable.

In the first category the states which have both favourable effects are Assam, Bihar, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and the Union territories of Goa, Daman and Diu and Pondichery.

The states which have both unfavourable region and structure effects are Andhra Pradesh, West Bengal and Union territory of Delhi.

Relative importance of the Region and Structure effects

For studying the relative importance of the Region and Structure effects, a multiple linear regression of structure constant productivity, p_j (s), and rate constant productivity, p_j (r) with average regional productivity, p_j, was run. The regression results are :

$p_j = 2.61048 + 0.50070^{*}\ p_j(s) + 0.17045\ p_j(r)$

S.E.	0.16003	0.39982
t	3.12193	0.42631

$\bar{R}^2 = 0.25444$; $F = 5.09538$; D.W. $= 2.10188$.

(*significant at 99% level of confidence.)

The coefficient of structure constant productivity gives the importance of the region effect and the coefficient of rate constant productivity indicates the importance of the structure effect in overall regional productivity variation.

To look into the problem of multicollinearity among the explanatory variables the correlation matrix has been determined :

	p_j	$p_j(s)$	$p_j(r)$
p_j	1		
$p_j(s)$	.55761	1	
$p_j(r)$	−.11749	−.33754	1

The correlation between $p_j(s)$ and $p_j(r)$ is statistically insignificant.

The regression significantly explains the variation in average regional productivity because of the region and the structure effects, since the F-value is significant ($F_{0.05}(2,22) = 3.44$).

It is observed from the regression results that the region effect is more important than the structure effect. The coefficient of structure constant productivity is significant at 99% level of confidence. The coefficient of rate constant productivity is statistically insignificant.

The results seem to be plausible because in the total industrial production, the weight of the industries having out-moded technology, obsolete plant and machinery is much higher than those having modern technology, plant and machinery. Therefore, the local factors are relatively more important in explaining the regional variations in productivity.

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Towards New Technological Frontiers

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Genetic engineering, single cell protein fermentation, immobilised enzyme systems, cell fusion, monoclonal antibodies and plant cell culture are some of the facets of modern biotechnology. Although only in the early stages of application, biotechnological applications will undoubtedly have a profound impact on agricultural and livestock production, renewable energy, waste disposal, the pharmaceutical industry, food processing and mineral extraction according to the authors.

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A plethora of literature now exists on the new frontier technologies and on their likely dramatic effects on the economic, social and political situation in advanced as well as developing countries. More similar studies are in the pipeline. The majority of these investigations are of a partial nature which herald a doomsday in the wake of the new technological advances. We argue that most of these studies (with few exceptions) tend to exaggerate the negative effects of new technological developments without giving due weight to the compensating positive effects on productivity, output and employment growth. This is partly because the studies are *partial* and do not consider the effects of technological developments on overall, intersectoral economic growth. This results in ignoring the compensating positive effects. We therefore devote Section I below to an examination of technologically-induced growth with special reference to the concept of the product cycle. Section II extends this analysis to the impact of new technologies on the international division of labour or the comparative advantage/disadvantage of developing countries. In Section III, we examine the socio-economic effects of new technological developments with special reference to possible losses of employment and changes in skill composition particularly in respect of women. We argue that a selective blending of new technology with traditional activity in developing countries is likely to mitigate these adverse socio-economic effects. Finally the concluding section makes some general remarks on the frontiers of new technologies like biotechnology and new materials, and the indeterminacy of their employment effects in the present state of our knowledge.

Technologically-induced growth

To say that contemporary macroeconomics is in a chaotic state may sound severe but consider the varying perspectives and policy prescriptions of conventional Keynesians, monetarists, supply-siders, post-Keynesians, natural raters and rational expectationists. Furthermore these various schools of thought overlap and combine in bewildering permutations of recipes for escaping global economic stagnation. It is then refreshing, and perhaps instructive to observe the resurrection of an older and simpler explanation of extended periods of economic "booms and busts", the theory of long-wave cycles.

Since its conception by earlier economists such as J. van Gelderen and N.D. Kondratiev[1], alternating swings of prosperity and decline, an entire cycle lasting from four to six decades, have been explained by the discontinuity of capital investment. In the 1930s Kondratiev saw the problem centring on the fluctuation and duration of investment in fixed durable capital goods, especially construction. Joseph Schumpeter shifted the focus to the recurring irregularity in the pace of technological innovation. G. Mensch and Christopher Freeman have recently updated Schumpeter's thesis and added a firmer empirical dimension to the argument.[2]

In its barest outline long-cycles, as seen by Freeman and his collaborators,[3] are explained by an eruption of major new technologies that are based on years of prior scientific investigation. The appearance of new technological frontiers stimulates investment, leads to falling relative prices of goods associated with the new technologies, and owing to competitive pressures, forces lagging firms to invest in the new processes in order to survive. Economic growth rides the crest of the technological explosion until countervailing forces begin to predominate. The technologies eventually mature and competition shifts the composition of investment more towards labour-saving and material-saving innovations. Economies of scale are achieved as the technologies become more routine and further reduce the demand for labour. Economic activity and the level of employment decline until the next cluster of technologies burst on the scene.

The case for a regular, long-wave cycle is hardly proved since there remains conceptual and empirical questions of causation and timing.[4] However, the immediate global issue is not whether there is a predictable, recurring long-term oscillation of economic activity, but whether the current cluster of newly emerging technologies will alter world investment propensities sufficiently to support a sustained period of economic expansion lasting throughout most of the rest of this century. This is a matter that could easily be treated as a national issue, yet the far reaching nature of the technologies under consideration and the close interaction among national economies renders an international scope more appropriate. Clearly different institutional mechanisms will be required to deal with rapidly advancing technologies in a context of stagnant employment, inflation and supply-shock ridden economies *vis-a-vis* a global economy characterised by expanding real output, improving productivity, and more optimistic psychological outlooks on the part of labour, business, government planners and consumers. The crux of the issue is whether labour-displacing tendencies of newly introduced modes of production can be overwhelmed by their ability to inspire a higher level of productive investment (See Section III below).

New technologies and the international division of labour

The shifts of relative costs of goods and services exchanged internationally, often referred to as dynamic comparative advantage, frequently have a powerful technological underpinning. These changes can be

1. Often long-wave cycles are referred to as Kondratiev cycles.
2. For a discussion of long waves, see Christopher Freeman (ed.), *Technical innovation and long waves in world economic development*, special issue of *Futures*, Vol. 13, No. 4, August 1981.
3. Christopher Freeman, John Clark and Luc Soete, *Unemployment and technical innovations: A study of long waves and economic development*, London, Frances Pinter, 1982.
4. For a critique of long wave thesis, see Nathad Rosenberg and Claudio R. Frischtak, Long waves and economic growth: A critical appraisal, *American Economic Review*, Vol. 73, No. 2, May 1983.

quite uncomplicated and direct, as witness the dampened world demand for sugar partly resulting from new industrially produced sweeteners or the decline in the use of copper that is predicted to follow optic fibre penetration of the communications market.

Other technologically-induced modifications of trade patterns can be more subtle. Perhaps the best known and documented thesis is the "international product cycle" attributed to Raymond Vernon. An innovating country, usually a wealthy, industrialised nation, introduces an improved production process or a new product and subsequently becomes an exporter of the successful innovation. Gradually, however, the technology becomes more routine as initial "bugs" are worked out and production becomes more amenable to mass production techniques relying on skilled blue-collar workers. In addition, the development of reliable marketing channels and observable demand for the process or product reduces the risks for imitating entrepreneurs, and eventually importing countries assimilate sufficiently the managerial, marketing and technical know-how to tackle domestic production utilising the particular technology. The eroding monopoly rate of the innovating country, learning by the early importing countries, and the typical labour abundance and lower wages prevailing in the non-innovating countries, combine to tilt the comparative advantage in favour of the new producers. If this process continues the original roles of the exporter and importer can reverse and the innovating country finds itself consuming imported goods produced with the mature, routinised technology previously spawned and exploited within its own borders. Although this idealised exposition of the product cycle obscures considerable variation around the central theme displayed by individual processes or products, it offers a reasonably close fit to the global relocations of the textile industry, and more recently for the production of automobiles and steel.

One may, however, be justified in raising two issues at this juncture : the first having to do with the relevance and viability of the product cycle in the broad scheme of development. Seldom have very low-income regions been on the beneficial end of the product cycle. Usually technology has spread among developed countries themselves, or to the more technologically advanced, "newly industrialising countries". What chance, if any, do the least developed nations have to experience substantial improvements in the volume, structure and technological character of their exports due to the assimilation of technology ? There is also an equally fundamental question as to whether the newly emerging technologies are imbued with attributes uncharacteristic of past technologies, which render them largely incompatible with the capabilities of even the most advanced Third World entities to transfer, assimilate, adapt and utilise competitively.

A second issue revolves around the possibility of an additional phase of the product cycle superimposed on the classic version in which newly emerging technologies shift comparative advantage *back* in favour of originally innovating and exporting developed countries. Sometimes referred to as the "reindustrialisation" of developed countries or the "restructuring of world industry, the focus is centred mainly on micro-electronics.

Exports of labour-intensive manufactured items such as textiles, garments, leather goods and footwear, have increased dramatically for the Third World over the last 15 years. They account for large proportions of total manufactured exports of developing countries.[5] Yet precisely these types of products that are produced by a number of discrete stages are ripe for the application of labour-saving micro-electronic devices. Hoffman and Rush go into some detail regarding events in the garment industry.[6] Laying out patterns and cutting cloth, traditionally time-consuming tasks involving highly developed manual skills, can now be done by computerised optimal pattern layout with electronically-controlled cutting by either laser or high pressure water jets. One firm cut this segment of its

5. Labour-intensive products account for 97 per cent of manufactured exports for India and 73 per cent for Egypt; over 40 per cent for Hong Kong, Republic of Korea and Singapore; and over 20 per cent for Argentina, Brazil and Mexico. See Kurt Hoffman and Howard Rush, Microelectronics Industry and the Third World, *Futures*, Vol. 12, No. 4, August 1980, p. 291.
6. ibid. pp. 293-294, and Kurt Hoffman and Howard Rush: *Microelectronics and clothing: The impact of technical change on a global industry*, (Geneva, ILO, forthcoming).

workforce from 200 to 20 skilled workers plus saving 8 to 15 per cent on cloth wastage. Microelectronics applications with similar repercussions on demand for labour are taking place in electronically-controlled sewing of buttons, pockets and collars. New photo-electronic edge-sensing equipments have been devised that permit robotic sewing machine heads for stitching and heat-based fusing techniques that are taking the place of sewing of collars, cuffs and long seams.

Similar trends are afoot in other labour-intensive industries. Automatic insertion techniques and automated testing have caught on in the Japanese electronics industry and is increasingly used elsewhere. The economic feasibility for wider application of micro-electronics in labour-intensive production processes is likely to grow as costs fall and technical problems are solved. Third World comparative advantage resting on abundant low-wage, semi-skilled labour is being threatened. Few believe that this will entail an immediate shut down of production-sharing plants in developing countries, but a drying up of new investment in such facilities is a distinct possibility, especially as parent firms extrapolate current trends in technology and costs over the productive life of a new plant.

It is clear then that science and technology policy interfaces with international competitiveness, through far-reaching effects on world commerce which in turn impinge on employment, balance of payments, foreign exchange stability and the management of international debt.

Socio-economic effects of new technologies

The advent of new technologies, particularly micro-electronics, has been received with mixed feelings. While the role of these technologies in raising efficiency, productivity and product quality is recognised, pessimistic forecasts have been made of the drastic reductions in labour requirements that are resulting or are likely to follow the introduction of microelectronics for example. Loss of jobs in printing industry, colour television production, telecommunications manufacturing and cash register manufacturing, are cases in point.

Conflicting evidence on employment effects

It is noted that employment in European banking and insurance industries has stagnated presumably because of the use of microelectronics devices. A French investigation predicted that computerisation in France will create thousands of jobs in services but at the same time eliminating 200,000 jobs by 1985.[7] In the United Kingdom, a study by Barron and Curnow forecasts a level of unemployment in the U.K. of 16 per cent of the labour force by 1990 partly due to labour displacement by microelectronics. The estimate is more optimistic than that of Jenkins and Sherman who foresee a 25 per cent level of unemployment by that date. An unpublished study by the Siemens Company warned that by 1990, 40 per cent of the German office jobs could become obsolete.[8] In 1978, the Swiss Institute, *Prognos*, predicted a 4 per cent rate of unemployment in 1990 for the Federal Republic of Germany assuming no new microelectronics applications, and a 12 per cent rate assuming their large-scale applications.

More recently, the Institute of Labour Market and Occupational Researeh of the Federal Republic of Germany analysed technical change in six sectors (viz. synthetic materials, wood, food-processing, metal-working, printing and retail trade) to examine, *inter alia*, employment effects. On the average, the employment effects are positive and this is accounted for mainly by economic expansion.[9]

Not all findings are pessimistic, however. For example, in 1978, the German Institute for Systems Engineering and Innovation Research asserted that

7. Cited in Z.P. Zeman, *The impacts of computer communications on employment in Canada: An overview of current OECD debates*, Montreal, Institute for Research on Public Policy, November 1979, p. 10.
8. Ian Barron and Ray Curnow, et al: *The future with microelectronics: Forecasting the effects of information technology*, London, Frances Pinter, 1979; and Clive Jenkins and Barry Sherman: *The collapse of work*, London, Eyre Methven, 1979.
9. W. Dostal, *Bildung und Beschaftigung imp technischen Wandel*, Beitrage zur Arbeitsmarkt und Berufs-forschung No. 65 (Nuremberg, Institut fur Arbeitsmarkt und Berufsforschung der Bundesanstalt fur Arbeit 1982); cited in ILO, *World Labour Report*, Vol. 1, Geneva, 1984, Chapter 7.

microelectronics had a negligible impact on employment and would continue to play minor role in this regard. Moreover, some predictions have not been fulfilled. Almost a decade ago job losses in office work were forecast for Sweden, but in fact the total amount of office workers in the late 1970s had increased. Third, the microelectronics revolution, through the creation of new products, services and industries, creates new concomitant demand for labour. Total employment in the United States computer industry itself more than doubled, an increase of around 200,000 jobs from 1972 to 1980 despite increases in labour productivity. Apart from this positive employment effect, the new products are also more beneficial and appealing to the consumers since they are often superior in quality and variety besides being cheaper. Few investigations are at present available which estimate the employment consequences of increased labour demand for existing goods and services as costs decrease and quality improves. This is partly because there is as yet no systematic methodology for the estimation of direct and indirect employment effects. Most studies do not take into account the stimulating effects of innovation on investment and consequent improvement at the macro-economic level. Furthermore, the pace of investment in new technologies depends on the rate of diffusion which in turn depends on the general economic situation and the rate of economic growth. One reason why in many countries the negative effects of microelectronics on employment have been less drastic than expected is the long economic depression in the advanced countries which slowed down the application of microelectronics and other new technologies. Finally, in the case of many frontier technologies other than microelectronics (namely, biotechnology, new materials and solar energy technologies) there is no *a priori* reason to suspect a net deleterious effect on total employment.

Conflicting employment forecasts result from the divergent assumptions which are made by their authors concerning productivity and output growth, and the rate of diffusion and applications of new technologies. Many of the employment forecasts have failed to take into account the "compensating employment effects" of new technologies. For example, the introduction of new technologies contributes to the expansion of output which in turn requires additional labour;[10] albeit after a time-lag. A variety of compensating effects can partly offset the negative direct effects of the application of new technologies. In principle, new technologies contribute to productivity increases and reduction in unit costs of production. The resulting lower prices can raise the demand for products at home and abroad. Thus, the introduction of new technologies is only one of the factors determining levels and trends of employment, others being: expansion of international trade, real wage levels, and macroeconomic policy, etc.

According to Luc Soete:

> "For this period (1975 to 1980) and in particular the most recent years, it is difficult to say much about an underlying trend towards further rationalisation and technical change job-displacement. For the post-1970 period, it is indeed difficult to separate the business cyclical, recessional employment effects of the fall in output growth, from the long-term "structural" employment displacement effects of technical change. The fall in productivity growth...suggests however that the latter has only had a minor effect on the present (1979-81) employment crisis.....It seems as if the question as to the possible impact of new technologies on employment is, within the present economic climate rather trivial. If only "new" technologies could stimulate and induce the system to higher growth levels seems somehow a far more relevant question..."[11]

Despite the inability to determine accurately the net job losses or gains, labour unions are understandably

10. On this point, see *Employment and Technical Change: A New Wave or the Past Revisited*, paper submitted by the Government of the United Kingdom to the Seminar on the Assessment of the Impact of Science and Technology on Long-Term Economic Prospects, Rome, Italy, 16-20 May 1983.
11. Luc Soete, Technical Change, Catching up and the Productivity Slowdown, in Ove Granstrand and Jon Sigurdson (eds.), *Technological and Industrial Policy in China and Europe*, Occasional Report, series No. 3, Research Policy Institute, Lund, pp. 100-101, 1981.

facturers as sub-contracters. Therefore, their choice of technology and investment decisions are influenced by their parent firms' target price and quality of products.[16] The introduction of NC-machines is a response to the need for raising product quality and reducing production costs to compete successfully in the international markets. NC-machines help to reduce production time e.g. by cutting lead time and save on scare skilled labour. Their widespread application is also due to the changes in consumer demand during the 1970s. NC-machine tools, with their varsatility in small and medium batch production, have the capacity to meet a diversified pattern of demand.

Since the work cycle of NC-machine is between 30 minutes and 2 to 3 hours, household enterprises are enabled to oparate without interruption while the members of the family watch TV, have dinner, etc. Furthermore, in the case of the machining center, a single machine can serve the purpose of several different

1950s, employment and output have grown in the Italian (Prato) textile industry quite consistently. This is in sharp contrast with the trends prevailing in other European countries. Between 1973 and 1980, the European Economic Community had a labour redundancy in textile industry amounting to more than half a million workers and representing a decline of 28 per cent. During almost the same period (between 1973 and 1981), the textile output fell by 6 per cent. Italy and Prato) seem to have withstood tendency towards employment decline in textile industry better than other EEC partners. Notwithstanding the introduction of modern innovations the Italian woollen textile industry registered an increase in its employed labour force. It is reported that between 1970 and 1975, the number

Table 1

Development of the Industrial District of Prato*: Textile Industry

2. Small-scale production of microcomputers in Argentina[21]

In 1977, a small Argentinian firm started producing microcomputers and various peripherals (e.g. data conversion devices) at fairly low scale of output to meet the needs of the domestic market. By November 1979, the firm was selling about "20 machines a month including several units of a microcomputer system involving a central processing unit and memory, visual CRT display, data conversion devices, and printer". One of the main competitive advantages of the firm is its "up-to-date knowledge of user needs in the Argentine domestic market coupled with the ability to rapidly translate this information into the research development and marketing of conveniently designed hardware and purpose designed applied software.....".

The small Argentinian firm has been quite successful for several reasons. First, as noted above the firm has the knowledge of user needs. This is indicated by its experience in the use of its product in the banking industry. The firm developed the necessary software and operator training directly in Spanish for the banks; combined with this, on-the-spot presence of the firm's representatives were the reasons for its success. Second, the firm was wise in choosing staff with accountancy and systems experience which enabled it to deal quickly with the clients' problems. Third, the firm has benefited from the high productivity and the motivation of its research teams.

3. Electronic load-controllers for hydroelectric power generation in Colombia, Sri Lanka and Thailand

An electronic load-control device for hydro-electric power generation is in operation in Colombia, Sri Lanka and Thailand. The sophisticated electronic control significantly reduces the feasible scale of hydro-electric generation of power. It makes possible the use of decentralised power sources, has no adverse effect on local employment, and provides a dependable source of power that is cheaper than available alternatives. Local manufacturing of the devices is being initiated in Thailand.

In Colombia in 1982, the Intermediate Technology Development Group (ITDG) financed a water-powered saw mill and electric generator to demonstrate how water power can be competitive with other energy sources in the 10 kw to 100 kw range[22] An electronic load-controller was used in the saw mill so that when power was not used by the saw for cutting the electricity generated by the alternator would temporarily increase and the load-controller would divert it into an auxiliary load in heat storage cookers. The local community volunteered labour to build the power house/saw mill, lay the penstock pipes and erect the transmission lines to the houses.

In Sri Lanka, a tea estate added an alternator with a load-controller to an existing turbine in a hydro scheme which provides sufficient power to drive fans in the withering section. The scheme is operated by an existing employee as an addition to his current responsibilities.

In Thailand, load controllers are being made in the training workshop of the National Energy Administration (NEA) by the electrical instructors on a part-time basis. This local assembly represents a saving of 51 per cent on the complete unit supplied from the United Kingdom. It also compares very favourably with the hydraulic governors being imported from China.

Within the United Nations System, the Advisory Committee on Science and Technology for Development (ACSTD) has given stimulus to the thinking and formulation of projects on the blending of new and traditional technologies. Under its auspices, an *ad hoc* panel was held on the subject in Los Banos in Decem-

21. Philip Maxwell, Specialisation decisions in electronic production—lessons from the experience of two Argentine firms, in S. Jacobson and J. Singurdson (eds): *Technological Trends and Challenges in Electronics*, Research Policy Institute, University of Lund, Sweden, 1983.

22. Gary Whitby, Electronic load-controlled mini-hydro electric projects: Experience from Colombia, Sri Lanka and Thailand, in A. Bhalla, D. James and Y. Stevens, *op. cit.*

ber 1982.[23] As a follow-up to this panel, at its Third Session, (February 1983), the ACSTD recommended that interested governments and organisations should initiate "pioneer" and pilot projects on integration of newly emerging and traditional technologies. It also recommended the preparation of a "portfolio" with a view to "drawing lessons from the successes and failures of such past on-going activities in both developed and developing countries."[24]

In response to this recommendation, the International Labour Office (ILO) prepared such a "portfolio" in close collaboration with the United Nations Industrial Development Organisation (UNIDO), International Rice Research Institute (IRRI), the 'Italian Commission on Nuclear Energy and Alternative Energy Sources (ENEA), and a number of individual scholars in developed as well as developing countries.[25]

The "portfolio" includes 17 case studies (in Latin America, Asia, Africa, and the advanced countries) and three chapters of a conceptual and policy nature. The case studies range from cloning of palm oil trees in Malaysia, to electronic load-controlled micro-hydro power operations in Colombia, Sri Lanka and Thailand to the use of photovoltaic power in Pakistan and Upper Volta, and to India's rural educational television broadcasting via satellites. The case studies feature the blending of newly emerging technologies such as microelectronics, biotechnology, new materials and solar energy technologies with such traditional economic sectors as agiculture, rural enterprises and small manufacturing firms.

Several conclusions derived from the above studies on blending are worth mentioning here. First, the blending of newly emerging technologies with traditional economic activities is feasible and can be successful. There is, of course, on balance, a benign socio-economic impact. There may be situations in which modernisation can only be accomplished through the introduction of new technology undiluted by traditional methods of production. However, enough evidence is now available to recommend that various degrees of blending at least be considered as options when frontier technology is introduced in developing countries. Also, the blending concept appears sound enough to recommend that any Third World policy coping with these new technologies include a dimension which supports successful technological integration.[26]

Second, many of the users of new technologies permit decentralised applications—this is specially true of microelectronics. But centralised physical infrastructure and services supporting the employment of the novel technologies, is a pre-requisite for a fruitful strategy of blending. Primarily this responsibility falls on the public sector in developing countries.

Third, successful blending requires a thorough knowledge of traditional techniques of production and the social, political and cultural conditions shaping traditional production. Aside from the purely technical aspects, such knowledge is necessary to ensure local participation in the use of the integrated technology and to be able to formulate a set of socio-economic criteria for selecting viable situations for a blending strategy.

IV. Concluding remarks

When discussing newly emerging technologies, there is a tendency to concentrate on microelectronics which is already being widely applied. However, one should bear in mind that other frontier technologies contain the seeds of revolutions of their own. Genetic engineering, single cell protein fermentation, immobilised

23. E.U. von Weizacker, M.S. Swaminathan and Aklilu Lemma (eds.), *New frontiers in technology application: integration of emerging and traditional technologies*, Tycooly International Publishing Ltd., Dublin, 1983.
24. ACSTD, *Report of the Advisory Committee on Science and Technology for Development at its Third Session*, Intergovernmental Committee on Science and Technology for Development, A/CN. 11, February 1983, p. 18.
25. See A.S. Bhalla, D. James and Y. Stevens (eds.) *Blending of New and Traditional Technologies: A Portfolio of Experiments and Projects*, op. cit.
26. For a discussion of this concept, see A.S. Bhalla and J. James, "An approach towards integration of emerging and traditional technologies", in E. von Weizacker et al, op. cit.

enzyme systems, cell fusion, monoclonal antibodies and plant cell culture are some of the facets of modern biotechnological applications will undoubtedly have a profound impact on agricultural and livestock production, renewable energy, waste disposal, the pharmaceutical industry, food processing and mineral extraction.

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"Even if I die in the service of nation, I would be proud of it. Every drop of my blood, I am sure, will contribute to the growth of this nation and to make it strong and dynamic."

October 30, 1984 — *Smt. Indira Gandhi*

₹ 84/168

Productivity
1984, XXV, 3, 343-351

Optimising the Traffic

A. S. NARAG
R. JAYASHANKAR

The present article deals with the establishment of the distribution pattern of the ports in India for light middle and heavy distillate products and thereby deduce the port traffic by taking re-course to an operations research technique.

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R. Jayashankar is a Lecturer in the University of Delhi and a Research Scholar of the Faculty of Management Studies.

Introduction

The real significance of ocean borne petroleum movement has been known to oilmen for almost as many years as the industry itself. Taking the foreign area in total and exlcuding the Russian block, almost eight barrels out of every ten barrels of oil consumption move along an ocean trade route between oil well and the final consumer. The advantages of transporting petroleum by water as against railway transport stem from the greater capacity of petroleum tankers, the simplicity of their loading and unloading and its cost effectiveness. Coastal shipping is generally accepted as the most energy efficient and cheaper mode of transport for carriage of bulk traffic over longer distances. The continuous search for adequate and economical means of transporting the ever increasing quantity of petroleum products from the sources to the points of consumption has led to the development of the modern efficient tanker.

The present article deals with the establishment of the distribution pattern of the ports in India for light middle and heavy distillate products and thereby deduce the port traffic by taking recourse to an operations research technique. The period considered is 1983-84. The Oil Co-ordination Committee which is entrusted with the task of synchronising the movement of Coastal tankers from port to port adopts a judgemental approach, and the distribution plan is not based on a precise measure of the cost elements involved in moving the product from port to port by tankers. The

Table X

Voyag Time

(Figures in days)

From to	Kandla	Okha	Bombay	Mangalore	Goa	Cochin	Tuticorin	Madras	Visaka	Haldia
Kandla	0	0.243	1.28	2.44	1.85	2.94	3.63	5.66	6.44	7.49
Okha	0.243	0	1.06	2.24	1.645	2.72	3.42	5.41	6.23	7.27
Bombay	1.28	1.06	0	1.31	0.715	1.80	2.5	4.5	4.08	6.36
Mangalore	2.44	2.24	1.31	0	0.595	0.493	1.187	3.225	4.012	5.05
Goa	1.85	1.645	0.715	0.595	0	1.126	1.82	3.82	4.63	5.68
Cochin	2.94	2.72	1.80	0.493	1.126	0	0.694	2.70	3.58	4.564
Tuticorin	3.63	3.42	2.5	1.187	1.82	0.694	0	2.25	3.104	4.129
Madras	5.66	5.41	4.5	3.225	3.82	2.70	2.25	0	1.012	2.23
Visaka	6.44	6.23	4.08	4.012	4.63	3.518	3.104	1.012	0	1.20
Haldia	7.49	7.27	6.36	5.05	5.68	4.564	4.129	2.23	1.20	0

Table XI

Cost details for a 25,000 deadweight tanker (excluding port charges and fuel)

(Consumed in the port)

(a) Victualling Cost (occ estimate)	—Rs. 100 per dwt per month	= Rs. 3.33 per dwt per day
(b) Fuel Charges (occ estimate)	—	
(1) Furnace oil	—35 MT of furnace oil per day @ Rs 1690 per tonne	= Rs. 59,150 per day
(2) Diesel	—2.5 MT of diesel oil per day @ Rs 3400 per tonne	= Rs. 8,500 per day
		Rs. 67,650 per day
		or = Rs. 2.706 per dwt per day
	Total of (a) + (b) =	6.036 per dwt per day

Table XII

Cost per Deadweight (Excluding port Charges fuel Consumed in the port)

(Figures in Rupees)

From to	Kandla	Okha	Bombay	Mangalore	Goa	Cochin	Tuticorin	Madras	Visaka	Haldia
Bombay	7.73	6.40	0	7.91	4.32	10.9	15.09	27.16	24.63	38.39
Cochin	17.75	16.42	10.86	2.98	6.80	0	4.19	16.30	21.23	27.54
Madras	34.16	32.65	27.16	19.47	23.06	16.30	13.58	0	6.11	13.46
Visaka	38.87	37.60	24.63	24.22	27.95	21.23	18.74	6.11	0	7.24
Haldia	45.21	43.88	38.39	30.48	34.28	27.55	24.92	13.46	7.24	0

The model

A number of industries are concerned with the distribution of a group of products using the same facilities. In many instances it is possible to consider this type of problem as an extension of the normal transportation routine and to develop a special computation routine for its solution (Haley, K.B. 1966)

p different refinery products are available at m loadports. The products are distributed to n disports at a cost which depends on the locations of m and n ports.

Denoting the amount that is sent from loadport i to disport j of the refinery product k by x_{ijk} and the Cost of sending one unit by C_{ijk} then it is required to

$$\text{Minimise} \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{p} X_{ijk} C_{ijk}$$

Subject to,

(a) Supply constraints of the loadports

$$\sum_{j=1}^{n} X_{ijk} = A_{ik}$$

$(i=1, 2, \ldots\ldots\ldots m)$
$(k=1, 2, \ldots\ldots\ldots p)$

(b) Demand constraints of the disports

$$\sum_{i=1}^{m} X_{ijk} = B_{jk}$$

$(j=1, 2, \ldots\ldots\ldots n)$
$(k=1, 2, \ldots\ldots\ldots p)$

$X_{ijk} \geqslant O$, for all i, j, k

The 'n' loadports are Bombay, Cochin, Madras, Haldia, Vishakapatnam and Kandla.

The 'm' disports are Kandla, Okha, Goa, Mangalore, Tuticorin, Bombay, Madras, Vishakapatnam and Haldia.

The 'p' refinery products are

(i) Light distillate—Motor spirit, Naphtha

(ii) Middle distillate—Aviation Turbine Fuel, superior Kerosene oil, High Speed Diesel, Light Diesel oil

(iii) Heavy distillate—Furnace Oil

C_{ijk} is the cost per deadweight ton (dwt) of the K^{th} product distributed from the i^{th} loadport to the j^{th} disport (Table XII).

This problem is very similar to the transportation problem, excepting the fact that there are three suffixes instead of two.

Results Of The Model

The product-wise monthly distribution plan has been summarised for light, middle and heavy distillate products.

Light Distillates

1. *Motor Spirit (M.S.)*

Loadport	Disport	Quantity ('000 mts).
—Bombay	Bombay	26.4
—Bombay	Kandla	0.2
—Bombay	Okha	0.4
—Cochin	Cochin	13.7
--Cochin	Mangalore	1.2
—Madras	Madras	7.9
—Visaka	Visaka	4.9
—Visaka	Kandla	0.1
—Visaka	Goa	1.9
—Visaka	Madras	1.1
—Haldia	Haldia	11.4

There will be a surplus of 600 MT in Haldia and 900 MT in Visaka, after the requirements at all the ports are met. The problem of Motor spirit surplus disposal would be further accentated with the commissioning of additional secondary processing facilities at several refineries. OCC may examine the export outlets from Haldia and Visakapatnam ports.

2. *Naphtha*

Loadport	Disport	Quantity ('000 mts)
—Bombay	Bombay	34.1
—Bombay	Goa	16.3
—Bombay	Mangalore	13.3
—Bombay	Tuticorin	13.1
—Cochin	Cochin	18.3
—Cochin	Tuticorin	6.1
—Madras	Madras	18.3
—Visaka	Visaka	6.2

There will be a surplus of 690 MT in Bombay, I7,100 MT in Haldia, and 6700 MT in Visaka. Surplus of 60,000 MT in Kandla, received from other refineries is fully for export.

Middle Distillates

1. *Aviation Turbine Fuel (ATF)*

Loadport	Disport	Quantity ('000 mts)
—Bombay	Bombay	34.00
—Cochin	Cochin	1.7
—Cochin	Bombay	0.2
—Madras	Madras	8.7
—Madras	Okha	1.0
—Madras	Goa	0.4
—Madras	Bombay	2.3
—Haldia	Haldia	7.7
—Haldia	Mangalore	0.2
—Haldia	Bombay	0.8
—Haldia	Visaka	0.7

The shortfall in Okha port of 800 MT can be met from Koyali refinery. Otherwise the All India Production of ATF can be matched, so as to meet the demand by making marginal adjustments at the refineries.

2. *Superior Kerosene Oil (SKO)*

Loadport	Disport	Quantity ('000 mts)
—Bombay	Bombay	24.0
—Cochin	Cochin	31.9
—Cochin	Mangalore	2.3
—Madras	Madras	33.5
—Visaka	Visaka	2.2
—Haldia	Haldia	15.0

Thus SKO movement will be only from Cochin port to Mangalore. The deficit at Bombay, Madras, Visaka and Haldia would be met ex-imports. Shortfall in Haldia port can be made good by movement from Koyali refinery.

3. *High Speed Diesel (HSD)*

Loadport	Disport	Quantity ('000 mts)
—Cochin	Cochin	84.6
—Cochin	Madras	1.6
—Madras	Madras	46.7
—Visaka	Visaka	51.6
—Haldia	Haldia	49.5
—Bombay	Bombay	149.7
—Bombay	Kandla	3.3
—Bombay	Okha	3.4
—Bombay	Goa	14.2
—Bombay	Mangalore	6.4
—Bombay	Madras	57.79
—Bombay	Visaka	18.6
—Bombay	Haldia	3.2

Bombay port would continue to be surplus in HSD, the total quantum of surplus being 106900 MT which would move coastally to practically all the ports which would be deficit, excepting Cochin. The deficit in Haldia port would be about 38600 MT, which would have to be met by imports.

Light Diesel Oil (LDO)

Loadport	Disport	Quantity ('00 mts)
– Bombay	Bombay	20.8
– Bombay	Kandla	0.8
– Bombay	Okha	1.8
– Bombay	Goa	0.7
– Bombay	Mangalore	0.3
– Bombay	Haldia	7.0
– Cochin	Cochin	1.8
– Cochin	Haldia	0.3
– Madras	Madras	4.8
– Visaka	Visaka	3.5
– Haldia	Haldia	20.0

The margimal deficit of 3900 MT at Haldia would have to be met from the refineries in the Eastern Sector.

Heavy Distillate

Furnace Oil

Loadport	Disport	Quantity ('000 mts
– Bombay	Bombay	21.8
– Cochin	Cochin	14.7
– Madras	Madras	19.6
– Madras	Visaka	13.1
– Haldia	Haldia	33.7

All the ports, excepting Madras will be deficient in Furnace Oil. Thus, furnace oil will have to be imported at all the ports except Madras. This is in confirmity with the government plan for 1983-84.

Conclusion

The distribution pattern arrived at in this study, for light, middle and heavy distillate products provides a basis for accurate and reliable traffic estimates at the ports in the country. Two considerations are of paramount relevance. First, as construction of port capacity invariably entails a long gestation lag due to technical and other procedural reasons, planning for port capacity expansion must be undertaken long before congestion builds up at ports. Secondly, since port capacity can only be used at specific locations and is not transferrable to other locations without involving huge losses, there is a great investment risk, if irrational traffic projections are made.

It will be useful to relate port traffic projections to existing port capacities to get an idea of the facilities required for the port development in the next two decades or so. A proper assessment of port capacity is essential both for optimal utilisation of existing capacity and addition to it to meet growing distribution needs for the petroleum industry. For an efficient tanker terminal the concept should be 'A Jetty should wait for ship and not the ship for jetty'. Therefore, in this respect it should be recognised that capacity of the port to handle traffic should be much in excess of the projected throughput.

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Productivity
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Wood Panel Industry

B.H. LALWANI

Even ten years ago, nobody would have even dreamt of the variety of uses to which timber is being put to, today. The use of these panel products is increasing with a rapid growth in buildings, furniture, railway and various other industries. As such the future of panel products industry seems to be bright in our country.

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According to the finding of an important study carried out by National Bureau of Economic Research in US, a developing country can move into manufacturing without making a very big capital investment as for example plywood business or other primary products which require large inputs of relatively unskilled labour. One of the basic rules of Lary in selecting the sea products is that such goods are actually being exported upto atleast $ 100,000. There is no crushing reason why India like the handful of Far Eastern countries who have walked away with most of the business, could not also be successful with such exports if it does not lose its labour cost advantage and if it organises itself properly to seize the opportunities. The International Trade Centre in Geneva has also identified export of plywood manufactures as a promising field for tropical countries like India. In 1964 studies by FAO predicted that by the year of which more than 3000 million would be imported. China's demand by 2000 would be staggering 20,000 million cubic feet a year by a population of 1500 million people. The requirement of an increasing population and growing standard of living will syphon much of the wood production into the home markets of developing countries. Asia, Pacific region supports $\frac{1}{3}$ of world population but has only 15% of its forests. Therefore, the prospect in the immediate future is one of wood drought.

With the spectacular rise of the log export trade and rapid increase in our overseas earnings from our wood based products forestry has become the "in"

industry. Presently the country is suffering from shortage in the supply of sawn timber required for various purposes and wood based panel products like plywood, particle board and fibre board can substitute the same with great advantage. Few people have realised the full impact and import of the Plywood industry particularly in a big country like India with its expanding—almost exploding—population. When one speaks of resources of a country, the forest resources form one of the outstanding ones and even in that timber resources loom large. Even ten years ago, nobody would have even dreamt of the variety of uses to which timber is being put today. Plywood industry spells efficient utilisation of this wonderful multipurpose product which over the years will be perhaps used only in a small proportion and even that as timber or firewood.

The supply of conventional species of timber used in sawn form by building the industry is getting scarcer with the passage of time and their prices are rising continuously in response to increasing requirements. A shortage of 6.3 tonnes of industrial timber is anticipated in 1985, the expected demand being 12 million tonnes per annum and the expected availability 5.7 million tonnes. Panel products promise to fill the gap which can be made from non-conventional species of wood and/or from waste material. By sophisticated processes even the weak varieties of timber are strengthened, transformed and converted into innumerable diversified products adding colour, strength, protection and bond in components and structures hitherto undreamt of. The use of these panel products is increasing with a rapid growth in buildings, furniture, railway and various other industries. As such the future of panel products industry seems to be bright in our country.

Panel products consist mainly of plywood, particle wood and hard boards. Today there are 70 plywood mills in the country producing plyood of different categories used for packing tea for export, etc. and general purposes decorative plywood, shuttering plywood, marine plywood, aircraft plywood, blackboards and flush doors as well as highly sophisticated products like parquet flooring, etc. The installed capacity is 60 million sq. metres. In 1975 India produced 46 million sq. metres of plywood worth about Rs. 30 crores. By 1980 installed capacity was to rise by 80% to 108 million sq. metres requiring additional machinery worth Rs. 20 million. In 1975 16% production i.e. 7.4 million sq. metres worth Rs. 43 million was exported to countries in Middle East, Europe, etc. There is no import. The capacity utilisation is 75%.

While the USA has a per capital consumption of plywood of 48 cubic metres, in Europe it is 6.3, USSR 5.9, Asia as whole 1.9, in India it is only 0.2 cubic metres hardly 3% of the world average. The main problem facing the plywood industry is the difficulty in getting sufficient raw materials. The present consumption of raw material 520,000 cubic metres was to rise to 800,000 cubic metres by 1980-81. The yield of veneers is directly proportional to the diametre of the logs which is becoming smaller. It is maximum at the girth of 1.2 metres and above. The quality of the logs is also deteriorating. There are many species of veneer log in use but the choice is restricted to good peelable species available in large sizes for economic reasons. The future development of plywood industry is closely dependent upon the development of forests in India and plantation programme of suitable plywood species. It takes about 70 to 100 years for a tree to become a peeler log. We have to adopt latest technology and effect maximum utilisation conserving our resources in an intelligent way for the benefit of the industry and the country. Technology must be developed for utili sation of unknown and new species for their utilisation in plywood industry on a top priority basis during the interim period. The other raw material is glue which is certainly quite costly in India. Similar is the case with the cost of PF, the production of which in the country is sufficient for the requirements of the panel product industry. The present cost of these resources is about 4 times the cost in the international market which accounts for the high cost of plywood in the country. Apart from high cost of resin adhesives there is about 4% excise duty on these accounting for the exorbitant cost of resin. It is possible to reduce the consumption of glue per unit area of plywood and effect reduction in its cost of production coupled with reduction in excise duty on synthetic resins. If we see the cost structure of plywood in the country, cost of timber is 47% and that of resin adhesive is 26%. The government

which has a monopoly in the control of forests must make available to all sections of the industry sufficient raw material at reasonable cost to maximise production for internal consumption as well as exports.

Most of the key machines for plywood industy are being imported. Though some small sector units have come up and produce some of the machineries like dryers, clippers, jowlers, etc. specialised machinery such as peelers, etc. have still to be imported so that quality material conforming to international standards could be put forth in the market. That such imports are being more liberally permitted by the government is a matter of good auspices for the industry. Korea, Taiwan and Malaysia have the dominant share in West Asian, and Gulf markets in wood panels as they have been able to cut down price in these markets since they get resin at Rs. 3300 per tonne while we get it at Rs. 13000 per tonne. Further they have modern well equipped plants in contrast to our old ill equipped machinery. The stoppage of cash assistance of 15% on plywood exports from 1.4.75 was an unwise step. The demand for panel products in Europe, USA and other markets of the West will further pick up in the near future with the progressive depletion of their wood resources and improvement in their economic climate and they will look to the East for meeting their demands for wood panel products.

A report of the symposium on world trade in plywood products organised by the Timber Committee of the United Nations Economic Commission for Europe held at Helsinki in May 1980 and published in "Finish Paper & Timber Journal" points out that the world trade in principle wood-based sheet materials, particle board plywood and fibre building board is concentrated in Europe and demand forecasts indicate a steady growth rate and a response of the industry to changed economic circumstances through the development of new products such as oriented strand boards (OSB), cement bonded boards and wafer-boards in the particle board sector, medium density fibre board (MDF) in the fibre building board sector and composite plywood product (combination of veneer plywood and other sheet materials e.g. plystrain, comply, etc). These new products extend the end-use sector with improvement in product performance. These developments anticipate an overall 2 to 4 percent annual growth rate for the industry in the next decade. Product development should concentrate not only on new types of board but also on energy conservation rationalisation of adhesive use, improvements in surface quality and finish and including a wide variety of laminates for end-uses in furniture construction, packaging and the use of panels in vehicles and shipping.

For the particle board industry technical development is at the centre of growth and along with improvements to the structure of panels especially higher grades for cladding and improved water repellent products for general construction. Such improvement together with the introduction of new board types will keep particle board industry the most buoyant in the panel sector.

For plywood consumption levels are expected to grow but European production is expected to fall as access to round wood supplies becomes tighter. This is demonstrated by significant gains made by South East and East Asian producers in the European market. Despite the advances made in peeling small diametre logs and the rational use of the whole log in composite plywood panels, European producers will not be able to resist import penetration except for the most modern and technologically advanced plants. European producers are aiming at more specifically end-use oriented products especially in constructions and furniture placing emphasis on the importance of performance rather than product oriented standards. Many of the producing nations have scored improved performance ratings though international normalisation has been slow because of a lack of jointly promotional activities between producers and consumers which should logically cross national boundaries in the direction of trade flow and also because of the differences in the market shares enjoyed by the different board types among nations.

The report stresses the need for technological development in the use of a fuller increase of the tree biomass to maintain product standard and resistance to procure from other wood users particularly in the form of industrial wood fuel.

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Productivity
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Capital Rationing for Mutually Exclusive Investment

M.S. TYAGI, H.K. MULCHANDANI
B.S. SHARMA

It is widely recognised that commonly recommended measure of investment desirability net present value (NPV), pay back period profitability, accounting rate of return (ARR) and internal rate of return, can occasionally give conflicting signals regarding the relative ranking of mutually exclusive investment. In the present study a mathematical technique has been applied for evaluation of mutually exclusive investments under different priority structures af desirability in measures of investment.

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Introduction

Government or businessmen are constantly faced with many decision problems which involves the investment of relatively large sums of capital for extended period of time. Generally those investments involve plant, property, equipment, product development and the purchase of fixed assets etc. because funds for large capital investment are scarce the various projects available to management at any given time is likely to be in competition with each other. Although some project will be given priority because of urgency of the situations, most investment should be studied, evaluated and ranked according to the long ranged advantage they promise.

The mutually exclusive proposals are eliminated and other must be ranked because of availability of limited funds. This is the situation when each of the proposals would have been acceptable, except that limits have been set by management on measure of investment desirability. Decision makers must develop a means of forecasting that takes advantage of technique which crystallize the relevant factors and help towards intelligent planning and decision making.

All over the world, the petroleum and petrochemical industries are growing very fast. As the crude oil prices are increasing frequently in world market, the petroleum scientists are engaged to develop processes

to use every drop of oil in optimal way. In the present study the investments are considered on the basis of petro-chemical industries because such projects involve the investment of relatively large capital at a great risk. A number of processes are available to produce different types of petrochemical with definite raw materials. Generally it is not an easy task to evaluate the mutually exclusive investment with many objectives. This study provides the systematic scientific evaluation for such investment problems.

Techniques of process evaluation

Basically, techniques for evaluating investment problems can be divided in to two groups i.e. unsophisticated and sophisticated.

(a) Unsophisticated techniques

There are two basic unsophisticated techniques for determining the acceptability or nonacceptability of investment alternatives. One is to calculate the accounting rate of return and the other is to find the pay back.

(i) Accounting rate of return (ARR)

The method determines the return by accurals method. It can be expressed by following formula :

$$ARR = \frac{C-D}{I}$$

Where ARR = Accounting rate of return

C = Annual Cash inflow (Cash saving after taxes)

I = Original investment

D = Depreciation

If cash flows are fairly uniform and the capital project has little salvage value, this method may be applied satisfactorily. The figures used in this method are based on the financial statement prepared under accrual accounting. This method was developed primarily to determine income and does not maximize the yield of capital project.

(ii) Pay back

Pay back is a method of calculating the required number of years needed to return the original investment from cash flows. The underlying concept is that, the sooner an investment is recovered the shorter the period of uncertainty regarding its growth. The mathematical expression is as follows :

$$P = I/G$$

Where P = Payback period

I = Original investment

G = Annual Cash inflows (Cash saving after taxes)

This method makes no attempt to measure the return on the capital invested. All it provides is the length of time that it takes to recoup the amount expanded on the project, the assumption being that projects with a short pay back period are better investment propositions than those with long pay back periods. The great disadvantage of this method, however, is that it takes no account at all of cash flows arising after the payback period has been completed. The emphasis in this approach is liquidity instead of profitability.

(b) Sophisticated Techniques

The following are the main two sophisticated techniques to evaluate the investment problem.

(i) Net present value (NPV)

The calculation on the net present value (NPV) of projects is probably the most commonly used sophisticated technique. The definition of net present value is given as NPV=Present Value of Cash inflow−Present value of investment.

It is found by substracting the net investment in a project from the present value of the cash inflows discounted at a rate equal to the firm's cost of capital. This approach assumes some minimum desired rate of return. The method can be expressed as follows :

$$PV = C \times F$$

$$NPV = PV - I$$

where PV = Present Value

C = Annual Cash in flow

F = Factor at a specified discount rate
(Present Value of an annuity of Rs. 1.00)

I = Investment

When the net present value approach is used to make "accept-reject" decision will be as follows :

$$\text{If NPV} \geqslant O$$

accept the project, otherwise, reject the project, i.e. if the NPV is positive, the firm will earn a return equal to or greater than its requires return or cost of capital.

The profitability index can be derived from above formula by applying the following equation,

$$\text{Profitability Index} = PV/I$$

The purpose of profitability index is to make the present value approach more meaningful to the management, but since it may in some cases lead to the selection of a project with a lower NPV, than the alternative proposal, it may not achieve its objective.

(ii) *Internal Rate of Return (IRR)*

Another discounted cash flow method is that of internal rate of return. This may be defined as "The rate of return at which the present value of the expected future receipts is equal to the cost of investment out lay". This technique entails trial and error computation. The mathematical formulation which expresses, this method of proposal analysis is as follows;

$$f = I/C$$

$$IRR = \text{Function (for L years)}$$

where f = Factor (present value of Annuity of Rs. 1.0 Arrears)

I = Investment

C = Annual Cash inflow

L = Life of Project

The Problem

The sources of C_2, C_3, C_4, unsaturated fractions are from fluid catalytic cracking (FCC) for refineries and steam cracking (SC) unit for petrochemical complexes. The purpose of FCC is mostly to produce motor gasoline, but propylene and butylene constitute a large part of the effluent, large excess of C_3's and C_4's olefinescoming from refineries and petrochemicals plants are available, and these excesses are expected to grow in the future. Therefore the management of refinery and petrochemicals are facing the problem of what to do with these excesses.

The three main uses of the fractions are production of chemicals, production of high octane component for the gasoline pool and production of steam cracking feedstocks or LPG. The present study deals with the production of chemicals. The C_2 stream is considered for production of ethyl chloride/tetra-ethyl-lead, which is an octane improver directly without actual separation of ethylene and ethane. Alternatively, the ethylene has been considered for production of ethyl alcohol (petro—Whisky) for export market. The C_3 stream is considered for the production of poly propylene, 2-Ethyl Hexanol and propylene oxide. The utilisation of C_4's elefine have been considered for Monyl-alcohol, Butyl-Rubber, Acetic Acid, and Butadiene. There can be number of feasible investment proposals to utilise the C_2,C_3 and C_4 constitute for production of chemicals, but the management finds that there are more acceptable investments than they have the capital to undertake. The objective of capital rationing is to select the group of investments that should maximise owner's wealth at minimum risk. Nine investments for production of chemicals from FCC off gases have been considered. The data considered for economic analysis is given in the table 1. Some data have been assumed purposely different from actual for making the problem more competative and complecative. Decision making will be more difficult where different measure of investments suggested the conflicting dicisions, and satisfaction of management desirability to achieve the minimum levels of measure of investment under predefined priority structure of measures.

The basic problem is to select the optimum combination of projects under the different priority structures of measure of investments. Such problems are best studied with the aid of quantitative approach. Nevertheless, the quantitative approach is indispensible because so many important financial decisions are basically of a quantitive nature. Even in decision that

are predominantly qualitative, quantitative analysis can be useful in measuring the measurable factors and thus in narrowing the areas of decision that must be made on a subjective basis.

The Data

Out of various possible alternative schemes for production of useful chemicals from F. C. C. off gases, nine schemes have been considered for evaluation. The project evaluation is based on the data given in table-1.

Table 1

Economic Data On Alternate investments

Investment Scheme	ECONOMIC DATA			
	Capital cost (000 Rs.)	Aunual Cash in flow (000 Rs.)	Desired rate of return (%)	Economic of thc project (Years)
I	26,350	10,000	14.0	5.0
II	42,960	15,000	12.0	5.0
III	9,000	3,000	15.0	5.0
IV	12,000	4,000	15.0	6.0
V	15,000	4,500	15.0	8.0
VI	20,000	5,000	15.0	10.0
VII	25,000	5,500	14.5	12.0
VIII	30,384	12,000	16 0	5.0
IX	38,430	14,000	14.0	5.0

The capital expenditure for each scheme has been evaluated with different techniques. The decision variables for evaluation of the projects have been calculated and given in table 2. The variables considered in the model are depreciation, payback accounting rate of return, internal rate of return, net present value and profitability.

The data has been assumed such that the all invest ment schemes are mutually exclusive and the goals are incompatible in the sense that these goals can not be satisfied fully at the same time.

Model Formulation

To formulate the goal programming model for investment selection the following variables are to be defined :

X_1 = Selection probability for investment i where i = 1,2,.....9

X_{10} = Total investment (,000 Rs.)

X_{11} = Annual Cash inflow (,000 Rs.)

X_{12} = Percentage of desired rate of return

X_{13} = Economic Life of Scheme in years.

X_{14} = Depreciation yearly (,000 Rs.)

X_{15} = Payback period in years.

X_{16} = Percentage of accounting rate of return.

X_{17} = Percentage of internal rate of return.

X_{18} = Net present value (NPV) (,000 Rs.)

X_{19} = Profitability Index

X_{20} = Total probability for project selection.

Absolute and Goal Constraints

The model is divided into three parts, i. e. absolute constraints, goal constraints and objective function.

(A) *Absolute constraints*

The following equations have been defined to sum up the decision variable value.

(i) Capital cost investment (,000 Rs.)

$$26,350\,X_1 + 42,960\,X_2 + 9,000\,X_3 + 12,000\,X_4 + 15,000\,X_5 + 20,000\,X_6 + 25,000\,X_7 + 30,384\,X_8 + 38,430\,X_9 = X_{10}$$

(ii) Annual Cash inflow (,000 Rs.)

$$10,000\,X_1 + 15,000\,X_2 + 3,000\,X_3 + 4,000\,X_4 + 4,500\,X_5 + 5,000\,X_6 + 5,500\,X_7 + 12,000\,X_8 + 14,000\,X_9 = X_{11}$$

(iii) Desired rate of return (%)

$$14.0\,X_1 + 12.0\,X_2 + 15.0\,X_3 + 15.0\,X_4\ 15.0\,X_5 + 15.0\,X_6 + 14.7\,X_7 + 16.0\,X_8 + 14.0\,X_9 = X_{12}$$

(iv) Economic life of the project (years)

$$5.0\,X_1 + 5.0\,X_2 + 5.0\,X_3 + 6.0\,X_4 + 8.0\,X_5 + 10.0\,X_6 + 12.0\,X_7 + 5.0\,X_8 + 5.0\,X_9 = X_{13}$$

Table 2

Calulated Values of Decision Variables for each Investment

Inevstment No.	Depreciation Yearly (000 Rs.)	Payback (Years)	Accounting rate of return (%)	Internal rate (%)	Net Present value (NPV) 000 Rs.	Profitability Index
1	5,270	2.635	17.95	26.00	7,980	130.3
II	8,592	2.864	14.92	22.00	11,115	125.9
III	1,800	3.000	13.33	19.87	1,060	111.8
IV	2,000	3.000	16.67	24.29	3,148	126.2
V	1,625	3.333	19.17	25.00	5,211	134.7
VI	2,000	4.000	15.00	21.43	5,122	125.7
VII	2,083	4.545	13.67	19.40	5,492	122.0
VII	6,077	2.532	19.50	28.00	8,904	120.3
IX	7,686	2.745	16.43	24.00	9,632	125.1

(v) Yearly depreciation (,000 Rs.)

$5{,}270\ X_1 + 8{,}592\ X_2 + 1{,}800\ X_3 + 2{,}000\ X_4 + 1{,}625\ X_5 + 2{,}000\ X_6 + 2{,}083\ X_7 + 6{,}077\ X_8 + 7{,}686\ X_9 = X_{14}$

(vi) Payback Period (Years)

$2{,}635\ X_1 + 2{,}864\ X_2 + 3.0\ X_3 + 3.0\ X_4 + 3.333\ X_5$
$4.0\ X_6 + 4.545\ X_7 + 2.532\ X_8 + 2.745\ X_9 = X_{15}$

(vii) Accounting rate of return (%)

$17.95\ X_1 + 14.92\ X_2 + 13.33\ X_3 + 16.67\ X_4 + 19.17\ X_5$
$15.0\ X_6 + 13.67\ X_7 + 19.50\ X_3 + 16.43\ X_9 = X_{16}$

(viii) Internal rate of return (%)

$26.0\ X_1 + 22.0\ X_2 + 19.87\ X_3 + 24.29\ X_4 + 25.0\ X_5$
$21.43\ X_6 + 19.40\ X_7 + 28.0\ X_8 + 24.0\ X_9 = X_{17}$

(ix) Net present value (,000 Rs.)

$7{,}980\ X_1 + 11{,}115\ X_2 + 1{,}060\ X_3 + 3{,}148\ X_4 + 5{,}211\ X_5$
$5{,}122\ X_6 + 5{,}492\ X_7 + 8{,}904\ X_8 + 9{,}632\ X_9 = X_{18}$

(x) Profitability Index

$130.3\ X_1 + 125.9\ X_2 + 111.8\ X_3 + 126.2\ X_4 + 134.7\ X_5 + 125.6\ X_6 + 122.0\ X_7 + 120.3\ X_8 + 125.1\ X_9 = X_{19}$

(xi) Sum of the projects acceptability

$$\sum_{i=1}^{9} X_i = X_{20}$$

(xii) Because of the seemingly endless need for funds it may be desirable to include a capital budget celling, limiting the funds available to the investments. This constraint may be formulated, as

$$X_{10} \leqslant 30{,}000{,}000$$

(B) *Goal Constraint*

(i) The management has determined that there should be at least 15.0 percent of rate of return i.e.

$$X_{12} - d_i^{+} = 15.0$$

where d_1^{+} is the positive deviational variable.

(ii) In order to maintain the minimum level of risk, the decision maker desires to limit the payback period to 2.8 years i. e.

$$X_{15} + d_2^{-} = 2.8$$

where d_2^{-} is the negative deviation from pay back period goal.

(iii) When the relative merits of a series of investment projects are under consideration, the

actual earning power of funds invested in a project is an important decision variable. The actual earning of power funds invested in a project is defined by internal rate of return. The minimum level of the internal rate of return has been fixed by the management, at 26% Thus

$$X_{17} - d_3^+ = 26.0$$

where d_3^+ is the positive deviational variable for the goal.

(iv) According to net present value (NPV) criterion a firm should accept all investment projects that would increase its net present worth and reject all others. For that reason, the management desired to fix the minimal level of net present value at 5,000 thousand rupees. i. e.

$$X_{18} - d_4^+ = 5{,}000{,}000$$

where d_4^+ is the positive deviational variable for net present value goal.

(v) The profitability index generally gives same decision as net present value, but sometime differs. For this study profitability index is considered as a goal with 125 as its goal level.

$$X_{19} - d_5^+ = 125$$

where d_5^+ is the positive deviational variable for profitability goal.

(C) Objective Function

The objective function for above problem is the minimization of the appropriate deviations which are weighted and/or ranked in the manner dictated by the priority structure of the problem as determined by the decision maker.

Level of goals and priority structures

Obviously capital budgeting is not an exact science and this is a topic which has just started to benefit from systematic objective approach in helping managers to choose from alternative proposals. After a discussion, the management fixes the different goals and level of goals for the project selection. The soundness or rationality of decision making is measured by the degree of organisational goals achieved by the decision. Therefore, the recognition of organisational goals provides the foundation for the need of a decision. Decision analysis is also constrained by maximum availability of total capital for investment etc. In order to explain the action of the goal programming on investment selection the goal and level of goals with different priority structures as considered for this study are given in table-3.

4.6 **Results and discussion** :

To demonstrate the capabilities of the goal program

Table 3

Goals, Goal Levels and Priority Structure

Sl. No.	Goal/Constraint	Level of Goals	Priority Structure					
			Case A	Case B	Case C	Case D	Case E	Case F
1.	Desired rate of return (%)	15.0	I W=1	I W=10	IV	II	IV	IV W=1
2.	Payback (Years)	2.8	I W=10	I W=1	IV	IV W=1	I	I
3.	Internal rate of return (IRR) %	26.0	III	II	I	III	II	IV W=2
4.	Net present value (NPV) (000 Rs.)	5000.0	IV	III	III	IV W=2	III	III
5.	Profitability Index	125.0	II	IV	II	I	IV	II

Note : W is the weight of priority.

ming model for project selection, a single set of goal level with six different priorities cases has been considered.

Case-A

The top priority is assigned to two different goals with two different weights. Although both payback and desired rate of return goals are considered in top priority but the weight assigned to them is 10 and 1 respectively. The second priority is given to profitability index and third is to internal rate of return. The last priority goal considered is the net present value.

The optimal solution obtained by goal programming model is given in the Table 4 in Case-A. The top priority goals have been satisfied fully, but the second priority goal is also achieved by 2.62 unit of profitability index. The third priority goal is also achieved exactly as assigned and the last priority goal is over

Table 4

Project Selection Probability and Optimal Solution

Sl. No.	Activity	Goal/Constrain Level	Case—A Priority	Case—A Result	Case—B Priority	Case—B Result	Case—C Priority	Case—C Result	Case—D Priority	Case—D Result	Case—E Priority	Case—E Result	Case—F Priority	Case—F Result
1.	Project I			0.34		0.38				0.16				
2.	Project II													
3.	Project III													
4.	Project IV			—		0.42		0.36		0.25		0.56		
5.	Project V													
6.	Project VI													
7.	Project VII			0.13										0.17
8.	Project VIII			0.53		0.20		0.64		0.59		0.44		0.83
9.	Project IX													
10.	Capital investment (000 Rs.)	30000.0		28084		21428		23162		24453		20192		28848
11.	Annual Cash Inflow (000 Rs.)			10401		7994		8888		9477		7562		10690
12.	Desired rate of (return %)	15.0	I W=1	15.0	I W=10	15.0	IV W=1	15.25	II	15.0	IV W=1	15.45	IV W=1	15.40
13.	Economic life of the Project (Years)			5.84		5.483		5.228		5.099		5.5572		6.01
14.	Depreciation yearly (000 Rs.)			5248		4117	4192	4492		4794		3815		5301
15.	Payback (Years)	2.6	I W=10	2.8	I W=1	2.8	IV W=1	2.634	IV W=1	2.588	I	2.8	I	2.8
16.	A.R.R. (%)			18.07		17.9		18.02		18.02		17.97		
17.	I.R.R. (%)	26.0	III	26.0	II	26.0	I	26.0	III	26.0	II	26.0	IV W=1	26.0
18.	NPV (,000 Rs.)	5000	IV	8054.8	III	6188.7	III	6658.0	IV W=2	7101.9	III	5711.4	III	8159.0
19.	Profitability Index	125.0	II	127.62	IV	129.9	II	125.0	I	125.0	IV W=1	127.9	II	125.0

achieved by 61%. The total investment is within the maximum limit and is very near to the constraint. The profitability of selecting the projects 8th, 1st and 7th is 0.53, 0.34 and 0.12 respectively. The total Economic life of the equipment given by the model is 5.84 years.

Case-B

In this case, the priority structure is not very different than in the Case-A. The top priority is given to the same goal as in Case-A, but the weights are exchanged. The second priority goal is assigned to the IRR and the third priority given to the net present value. The last priority goal is the profitability goal.

The optimal results are presented in the Case-B of Table 4. It is interesting to note that even a slight reshuffling in the priority structure changes completely the project selection probabilities. The first priority goals and second priority goal are achieved completely, but the third priority goals NPV, is over achieved by only 24%. The last priority goal is over achieved 4.93 unit profitability index. The utility of available fund is decreases ta 71%. The probabilities for projects No. 8th, 4th and 1st are 0.20, 0.42 and 0.38 respectively which are completely different from the Case-A.

Case-C

In case-C also the set of goals is the same as in case A and B. The first priority is given to IRR and the second priority is assigned to profitability index goal. The third priority goal is NPV and last priority is given to the payback and desired rate of return goal with equal weights.

The optimal results are presented in the Case-C of Table 4. The first and second priority goals are satisfied completely and the third priority goal is over achieved by 33%. The last priority goals are also over achieved. The fund utility increases to 77%. The probability for the selection of projects numbers 8th and 4th are 0.64 respectively.

Case-D

The first priority is assigned to the profitability index, second priority to desired rate of return, and third to IRR. The last priority is given to the goals NPV and payback period with 2 and 1 weights respectively. This priority structure is given as case D in table-4.

The optimal results show that the first, second and third priority goals have been achieved, but the last priority goals are over achieved. The NPV is over achieved by 42%. The total capital cost required only 81% of the funds available for projects. The projects selection probabilities for 8th, 4th and 1st are 0.60, 0.25 and 0.15 respectively.

Case-E

In case-E, the first priority is given to the payback period goal. In other words, the management desires that the payback period must be 2.8 years. The second priority goal is IRR and and the third priority is assigned to NPV. The last priority is given to profitability index and desired rate of return goals.

The optimal results indicate that the first two priority goals have been satisfied and the third priority goal is NPV which is over achieved by 14% only. The last priority goals are also over achieved. The maximum utility of the available fund is only 67%. The probability of accepting the different projects 8th and 4th are 0.45 and 0.55 respectively.

Case-F

In this case, again the top priority is given to payback period goal and second priority is assigned to profitability index goal to achieve the profit level. The NPV goal is considered on third priority and the last priority is assigned to IRR and desired rate of return goals with weight 2 and 1 respectively.

The Optimal results presented in Case-E of table 4 suggest that top priority goal is satisfied and second priority goal is over achieved with 0.277 units. The third priority goal is again over achieved by 83%. The last priority goal, internal rate of return, is also over achieved by 0.406%. The total utilisation of available funds is around 93%. Under the above priority structure for project selection the projects 8th

and 7th have sslection probabilities 0.83 and 0.17 respectively.

However, all the different cases are equally important with respect to their priority structures, but normally management tries to invest the whole money which is assigned for the projects. Further, the management is also interested to keep other decision variables at satisfactory levels. After reviewing different priority structures and optimum results it is found that the Case F is the most suitable under above constraints. Results shows that the capital utilization and net present value are at maximum levels and pay back and profitability levels are satisfactory.

Conclusion

A goal programming model has been discussed for optimum selection of petrochemical investments when management has multiple conflicting goals. The goal of desired rate of return was stated in the form of a goal constraint that must always be achieved or over achieved with small amount. The goals of maintaining of payback period and NPV were treated in such a way that positive and negative deviations respectively from these goals were assigned specified priorities.

The set of goals considered in the present study is clearly not the only one that is conceivable. In the above model the priority structures were so selected that the project cost varies from 67% to 93% of total investment available. Of course, the model can be readily modified in such a way that the most important goal would be to avoid any shortage in the absolute amount of profit.

The model can also be modified to have better distinction between policies for desired return, payback and NPV. For example, management might be willing to accept the 42% extra NPV only instead of increasing payback period by around 0.22 years. This kind of preference of management can easily be worked into the model.

Thus greatest asset of goal programing model comes out to great flexibility, which enables us to handle variations of the constraints and goals without difficulty. Indeed, Goal programming proves as an effective tool for project selection when management has incompatible multiple goals. By incorporating various components of the organisation and alternative, a goal programming project selection model can effectively analyse the interrelationship and the decision effects on a variety of management goals.

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Job Satisfaction : Some Correlates

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This paper studies the relationship between job satisfaction and some related variables. The higher the age, more the number of dependents, the lesser would be the job satisfaction according to the paper.

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Introduction

Job satisfaction comprises those outward or inward manifestations which gives an individual a sense of enjoyment or accomplishment in the performance of his work. It may be taken as a summation of employees feelings in areas which are directly or indirectly connected to the job. It seems plausible that healthy organizations are in some way more responsive to human needs so that satisfaction results directly or indirectly from the ability of the organization to meet those needs.

The needs of a human being are various, starting from the basics of food and shelter to social approval and self-esteem to self-actualization—Maslow (1943). Since Hoppock's Monograph on job satisfaction in 1953, a substantial amount of research has been conducted on this topic. Herzberg et al (1959) reviewed literature and found that there are two parallel and independent variables which are responsible for either job satisfaction or dissatisfaction. Factors causing job satisfaction have a very little tendency to cause job dissatisfaction and vice-versa. He found that in order to attain basic satisfaction, a worker must be able to experience achievement, recognition, the job of work, responsibility and advancement while the factors which led to dissatisfaction included company policy and administration, salary, inter-personal relations and working conditions. Income is a very important variable which influences job satisfaction. Herzberg et al (1957) state that wages tend to be rated as less important than

security, opportunity for advancement and company management but as more important than job content, supervision and social aspects of the job. Lahiri (1965) found that salary and security were ranked most important and personal growth less important. Later Lahiri and Srivastava (1967) found Herzberg's Model (1959) to be workable among middle management. Herzberg et al (1959) also pointed out that salary was associated both with satisfaction and dissatisfaction of employees. Vroom (1962) reports that it is often assumed that the context of the job is more 'ego-relevant' than are the physical and social characteristics of the work environment. On the other hand, when one considers correlational evidence—Lawler and Porter (1963); Smith & Kendel (1963) suggest that income level is positively related to job satisfaction.

In a more recent study Singh & Singh (1980) have found job satisfaction to be related to age, income, tenure, material status, education and number of dependents. Results indicate that job satisfaction is greatest during the first few years, decreases and increased with experience and that martital status does effect satisfaction. In a similar study Rao (1971) focused on similar variables and found that age, income, length of service and tenure were having little relationship while education, caste and skill had a stronger association with job satisfaction.

The present problem was designed to study (1) the relationship of job satisfaction with absenteeism, age, income, tenure and number of dependents; (2) Whether the two plants of the private factory differ on the above dimensions.

Methodology

Subjects: In all 62 male subjects, 31 from each plant volunteered to take part in the study. All the subjects were in the management cadre.

Procedure

(1) Muthyya's Job Satisfaction Scale consisting of 34 items was selected. The rating for job-satisfaction consisted of a three-point ranging from 0−1−2 where the scoring was done for job-dissatisfaction. The reliability coefficient for the job-satisfaction scale is 81 after applying the Spearman-Brown prophecy formula, significant at .01 level indicating satisfactory reliability of the scale.

(2) A personal data questionnaire was also designed consisting of items giving the name, age tenure, number of dependents, etc.

Both, Muthyya's job satisfaction scale and personal data questionnaire were administered to each of the subjects individually. The study was first conducted in plant I and then plant II of the same company. The data thus collected, was further analysed. Correlation between job satisfaction scores and income, age, absenteeism, tenure and number of dependents was found 't' was also computed to see whether the two plants differ significantly on the above variables.

Results

Results indicate (Table 1) that more number of dependents and a higher age contribute towards dissatisfaction. To look after a large number of persons, feed more mouths and providing the basic necessities of every day life makes a person dissatisfied and this is reflected in his work. Young people take their work as a challenge and, each opportunity as an opening towards a better future. They have a broader perspective to work in. Older people lack the enthusiasm which is observable in the younger ones. Older people take their work as a matter of routine and therefore the spirit behind it is lacking.

The results also indicate a negative relationship between job satisfaction and absenteeism. This however, does not imply that, the more a person absents himself from work, the lesser he is satisfied but, satisfaction helps him to absent himself less from work. He has a positive attitude and approach towards his work rather than having a negative approach of avoiding it by keeping himself away from the work environment. The results are in line with Vroom's theory that as satisfaction increases, absenteeism decreases.

It may also be observed (Table I) that tenure and job-satisfaction have a positive relationship. This also supports the above mentioned findings. A satisfied

person continues on the same job as, the job is instrumental in satisfying his basic needs (on the job) like affiliation and recognition. It gives the person a sense of being accepted by his co-workers, his skills being recognized and appretiated. This further generates a feeling of security thus, satisfying one of very basic needs of man (Maslow 1943).

Table—1

Correlations between job satisfaction and income, age, absenteeism tenure and number of dependents.

Variables	Plant I	Plant II
	Correlations	
Job Satisfaction and Income	+.65	+.72
Job Satisfaction and Age	—.33	—.28
Job Satisfaction and Absenteeism	—.27	—.31
Job Satisfaction and Tenure	+.55	+.32
Job Satisfaction and Number of Dependents.		

Table 2 indicates mean scores on job satisfaction, income, age, absenteeism tenure and number of dependent of both plant I and plant II along with the 't' and 'p' values. The mean scores are generally higher for plant II. The two plants differ significantly on age and tenure (Table 2). While there is no significant difference between the two plants on job-satisfaction, income, absenteeism and number of dependents.

Table—2

Variables	Mean Scores Plant I	PlantII	't'	'p'
Job Satisfaction	16.74	16.86	0.16	N.S.
Income	1274.70	1479.09	1.48	N.S.
Age	34.00	44.10	5.01	.01
Absenteeism	2.62	2.42	0.57	N.S.
Tenure	7.42	17.06	4.11	.01
Number of Dependents	2.32	2.87	1.22	N.S.

Figure 1 shows graphically the correlations between job-satisfaction and income, and tenure. And figure II shows negative correlations between age, absenteeism and number of dependents. It can be observed that correlation in general are higher in plant 1 as compared to that of plant II except for two, income and absenteeism.

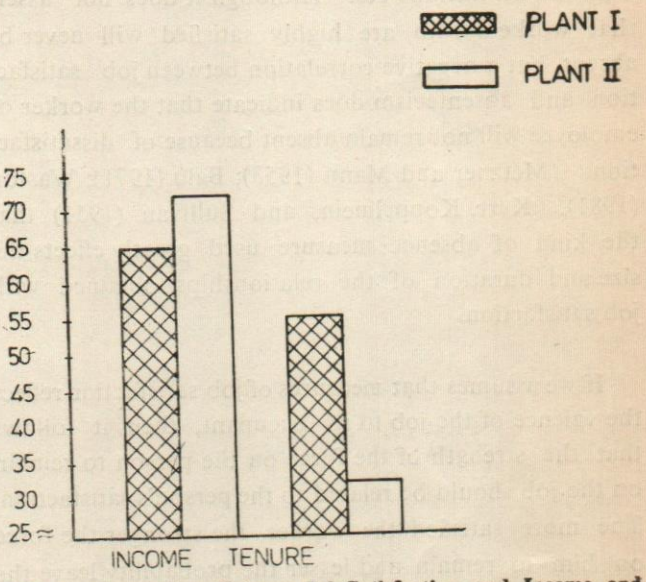

Fig. 1 Correlations Between Job Satisfaction and Income and Tenure in Plant I and II

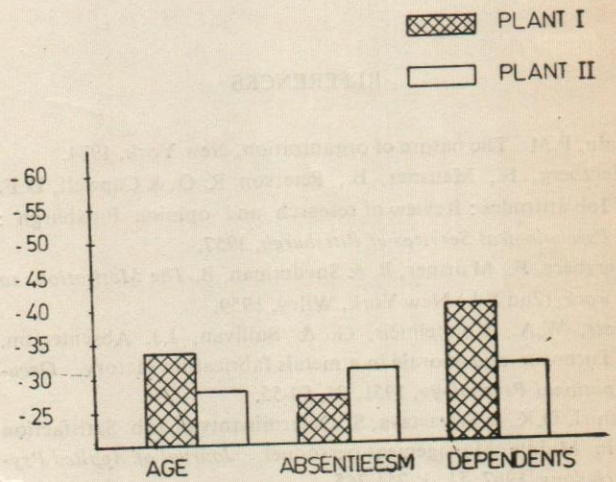

Fig. 2 Correlation Between Job Satisfaction and Age Absetieesm and Number of Dependents in Plant I and II

Income is an important variable which influences job-satisfaction. Rajbir and Vasudeva (1976) found a significant relationship between pay and job-satisfaction among skilled workers. Sinha and Aggarwal (1971) found that middle income persons are more satisfied than lower and higher income groups. It has also been

observed that age is an important determinant of job-satisfaction. Singhal (1974) found job satisfaction to be highest in the first year because of positive attitudes and tapers to its lowest level in the work life of an employee due to successive competitions of the self-concept and aspirations etc. Although it does not assert that workers who are highly satisfied will never be absent, but a negative correlation between job satisfaction and absenteeism does indicate that the worker or employee will not remain absent because of dissatisfaction. (Metzner and Mann (1953); Balu (1971); Waston (1981). Kerr, Koppelmein, and Sullivan (1951) that the kind of absence measure used greatly effects the size and duration of the relationships obtained with job satisfaction.

If we assumes that measures of job satisfaction reflect the valence of the job to its occupant, then it follows that the strength of the force on the person to remain on the job should be related to the person's satisfaction. The more satisfied the worker the stronger the force on him to remain and lesser the probability leave the job. West (1977) found job-satisfaction to be highly related to tenure.

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APPENDIX—I

Personal Data

Name	:
Age	:
Sex	:
Number of years on the present job	:
Number of jobs changed in the past 5-10 years	:
Dependents	:
Income	:
Education	:
Experience	:
Present Position in the Company	:

Productivity
1984, XXV, 3, 371-377

Automobile Production in India

M.L.V. RAMU

This paper highlights the problem areas related to the various classes of automobile production; suggests how best this can be overcome by standardisation and presents the future trends in the segment of automobiles to suit the varied sections of users to help maintain them easily at minimum cost.

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Introduction

With the advent of freedom, India was still in an infant stage in the automobile production. Prior to 1947, most of the automobiles used in our country were of British, American and Italian origin. Subsequently the rapid growth of industries coupled with the fast pace of life warranted the citizens to switch over to frequent use of various class of automobiles. Keeping in view the pressing demand of different class of vehicles, leading industrialists commenced their ventures with foreign collaborations in the key cities. These automobile production units duly earmarking vast area of land with other resources have invested huge capital amounts obtaining all specialist machines from the foreign countries and technical know-how over a period as per the terms and conditions entered into and approved by the Govt. of India. Now a stage has reached after 3 decades, that the diversity of production has gone leaps and bounds and the entire range is quite uncontrollable. This is a pointer to the fact that the expansion of automobile industry is attributable to the vision, foresight and consistant perseverance of private enterprise upto mid sixties (1965) and lack of planning and control on the part of Govt in so far as the future ill effects arising out of the diverse production of automobiles.

Object

This paper highlights the problem areas related to the various classes of automobile production; suggests how best this can be overcome by standardisation

and presents the future trends in the segment of automobiles to suit the varied sections of users to help them maintain them easily at minimum cost.

Scope

It is proposed to discuss the present limitations of the existing designs, development, tryout and users views, quality of raw materials, trade items used, production capabilities, inconsistance in quality on various components, sub systems and major assemblies that has crept in end product and poor vendor rating with regard to quality level and imprompt delivery schedules, areas hinting for variety rationalisation, consequent savings outcome and its impact on interchangeability during repair maintenance while equipment is off road.

The limitations are this paper would not go into alternative measures to suggest substitution for petrol or diesel in view of the fact that availability of these fuels might pose future problems. Also the technicalities of production will not be looked into as the techniques are quite unique in its versatility and each aspect has its own merits/demerits with the passage of time. The cost of the products will not be commented upon as the salient factors accounted for pricing embraces the inventory, vendors, labour welfare, pattern of taxes etc. All these parameters are variables as well as unpredictable (saddled) with unanticipated changes in fiscal policy at national level.

Type of automobiles in India

The existing automobiles on road may be classified as follows :

(a) Light duty two wheelers i.e. Mopeds (Four models) e.g. Luna, Suvega, TVS 50, Hero Majestic.

(b) Medium duty two wheelers i.e. Scooters like Bajaj, Lambretta, Vijai Super, Falcon, Pushpak etc. (Five models)

(c) Medium duty two wheelers—Motor cycle Royal Enfield, Bullet, Yezdi from (Ideal Jawa) & Rajdoot (Escorts) (Three models)

(d) Three wheelers—Autorickshaws (Bajaj and Lambretta) (Two models)

(e) Three wheeler for light luggage duty i.e. Tempo.

(f) Four wheelers for transhipment of goods upto $1\frac{1}{2}$ tons capacity e.g. Matador, Standard, Hindustan. (Three models)

(g) Cars—Standard, Fiat and Hindustan Ambassador. (Three models)

(h) Buses on Ley Land and Benz Chassis—Capacity 3 tons (Two models)

(j) Truck transporters

(i) 3 ton capacity

(ii) 5 ton capacity

(iii) 10 ton capacity and above.

(k) Jeep Willys and Hindustan Trekkers

The above may be roughly grouped as follows :—

(i) Three wheelers—Light and Medium duty —about 12 models.

(ii) Three wheelers—Autorickshaws—2 models.

(iii) -do- —For light luggage—1 model

(iv) Four wheelers upto $1\frac{1}{2}$ ton capacity—1 model

(v) Cars—3 models

(vi) Buses—about 3 models

(vii) Truck transporters—5 models

(viii) Jeeps—2 models

So the total number of vehicles models plying on road are about 29 types. Since these 29 models are distinctly separate from each other, one can just imagine range of components (A to *Z*) fitted in these 29 models, range of varying standards and the pertaining variety of maintenance tools handled.

Salient Points of the Automobiles in use

(a) From an examination of the cross section of automobiles, it is noticed that mopeds, Scooters, Motor Cycles, Autorickshaws, Three wheelers for light luggage duty, Cars & Jeeps are Petrol Engine driven.

(b) The designs of mopeds by and large indigenous.

whereas designs of Scooters, Motor Cycles, Cars and Jeeps are imported from different countries on foreign licences and subsequently developed and adapted to suit our Indian conditions for production.

(c) In the absence of adequate field trials in different enviroments/seasons, it is seen that components or sub assys in many automobiles are overstressed due to poor factor of safety and corroding fast on account of poor resistance to atmospheric effects.

(d) Use of raw materials like sheets, rods, tubes and random tested castings which have crept in the bulk stores and eventually launched into initial phases of manufacture under the assumption that materials conform to mechanical properties like tensile strength, surface hardness, impact strength, shear strength and compression etc. This is due to inadequate laboratory facilities to determine the chemical compostion and physical properties of the raw materials used as per laid down specifications and hence frequent failure rates.

(e) Lack of timely and periodical checking of production jigs/fixtures, contributing to assembly defects, misalignment and poor fabrication has resulted in premature breakdown of subsystem and assemblies in an automobile.

(f) Excessive relaxation in quality standards to meet the market requirements has resulted in delivery of sub-standard items/ end products.

(g) Lack of typification facilities in civil manufacture resulting in sub-standard items in end products.

(h) Insufficient lead time arising out of imprompt delivery schedules on the part of vendors and cutting short other formalities to gap up time lag in production schedules. The condition of fasteners speaks of its low quality attributable to absolute negligence on the part of ISI for not having exercised strict control with reference to the checking of characteristics of fasteners. This area is really a blot.

(j) Non uniform skill amongst workers, inconsistant quality in materials used; inaccuracies in the machines used, variable tool characterstic and lack of timely inspection for first off clearance add to quality variances and results in commulative errors/hetrogeneous products.

(k) Poor response from users in feed back to the producers has created a 'Void' and the necessary stimuli for value engineering, optimum standardisation and maintenance problems are totally missing in the eyes and minds of design and development, manufacturers, Agency for standardisation and users as well.

(l) No justification exists for a diverse production amongst the same class of products with no appreciable increase in performance parameters.

(m) The basic engine characteristics like cylinders bores, valves size and configuration of pistons, gudgeon pin, rings, connecting rod etc. varies in the same class of products with no additional benefits to the user.

(n) None of the fuel system in a diesel vehicle comprising fuel pump, fuel filters, fuel injection pump (in line type and rotary type) Injectors, oil pump for lubrication are interchangeable in the same class of products.

(o) Non-uniformity in the size/mountings of radiators for the same class of products have rendered vehicles idle due to delay in receipt of that particular radiator.

(p) Variation in specifications of starter motor, dynamo, cut-outs, fan belts, pulleys have posed repair problems in the same class of vehicles and slight variations in the models of these elertrical units warranted for new replacements and hence extra cost.

(q) No rationality in speed transmission Gear ratios for the same class of automobiles (four wheelers/ six wheelers) with the result possible interchangeabilities are totally ruled out. Also propeller shaft, spider bearings, bevel gear, differential gears wheel discs and its connected items are peculiar in the same class of vehicles.

(r) Different layout in electrical wiring, lightning

switches non-uniform watts and volts in bulbs used, insufficient fuse protection and initial starting current varying due to dissimilar engines and hence selective ampere hour batteries among the same class of truck transporters and buses.

(s) No timely co-ordination between engine designers and other ancillaries like fuel injection pump, injectors, fuel filter, radiator manufacturer etc. to optimise variety rationalisation and help achieve standardisation in matching range of components/sub systems among the same class of products.

Existing limitations in automobile production

Allowing for the industrial proliferation over a period of 15 years, a state of diverse production with no rationale planning has put the Government in a dilemma. Producers may have been correct in arriving at the requirement of the right type of private/public automobiles after a market survey but once these vehicles are put into use, it is not visualised in the run as what is the sum total effect of the various anomalies brought out in para 5 above. The brunt of the vagaries is borne maximum by the user who has invested the amount due to the obligations towards the product assurance having not been fully justified. The present trend is to change over from semiperfected designs to new ones and thereby the maximum capability not evaluated. Following draw-backs/difficulties noticed are listed below :—

(a) Most of the designs patents are imported ones.

(b) The available materials/fasteners/other items does not conform to the quality specifications called for in the imported designs.

(c) Having substituted the indigenous materials/items, the designs are not fully oriented/developed for adequate environmental tests to prove the pilot's endurance.

(d) poor feed back from user to producers about the behaviour of vehicles turned out.

(e) The engine designers and other agencies meant for ancillaries like fuel injection pump, Injectors, fuel filters, Radiators, oil pumps etc. have not co-ordinated in the direction of variety rationalisation and thus technical simplification is nil.

(f) Due to varying designs from different countries the standards in respect of quality/material and fasteners and special maintenance tools of different automobiles in the respective classes are quite unwieldy.

(g) Also variety inspection standards are to be maintained, inspectors are to be trained and proper execution to be ensured.

(h) Subsequent preventive and repair maintenance at various levels (Ist echelon, 2nd echelon and 4th echelon in the army language) i.e. minor, pertaining to major assy and overhaul not being handled by authorised agencies due to various reasons.

(j) Non-availability of the original spares of the vehicles for a minimum period of 5 years and resorts to fitment of spurious items readily available in the trade but not type approved.

(k) Non association of 'Indian Standard Institution' with automobile Engineers in streamlining the sub system/systems of automobiles for ensuring variety rationalisation and interchange ability.

(l) Designers in the electrical engineering possessed with more emphasis to electrical equipments of higher KVA ratings pertaining to the other engineering industries like machine tools, Hoists, Electronics and in other allied fields and less of attention to codify the starter motor, dynamo, out-out and battery used in automobiles.

(m) Dearth of special steel for manufacture of transmission gear etc has caused a shortage in the market.

(n) Non-regulation of proper electric voltage supply to automobiles has affected the accuracy of precision mechining boring and honing.

(p) Non-compliance of norms prescribed for determination of specific fuel consumption per BHP/hour, pattern of actual speed-load characteristics, permissible eccentric running ascertained from dynamic balancing tests etc during engine testing and so on.

Recommendations to overcome from the existing lacunae

Keeping in view of the end use of these vehicles

(29 models) it is suggested that the above may be conveniently regrouped in the following classes :—

(a) Class 'A' Vehicles—Truck transporters 10 tons and above

(b) Class 'B' vehicles—do-between 4 to 5 tons.

(c) Class 'C' vehicles—do- 3 to 4 tons.

(d) Class 'D' vehicles—Buses upto 3 tons capacity.

(e) Class 'E' vehicles—Jeeps upto 300 kgs.

(f) Class 'F' vehicles—4 wheelers and 3 wheelers upto 1½ ton capacity.

(g) Class 'G' vehicles—Cars-two types are permissible). i.e. small type for 4 passengers.

(h) Class 'H' vehicles—3 wheelers i.e. auto-rickshaws.

(j) Class 'J' vehicles—2 wheelers i.e. Motor cycle. (One model to be standardised).

(j) Class J1 vehicles—2 wheelers i.e. Scooters (only two models to be standardised)

(k) Class 'K' vehicles—Mopeds (for light duty) (only one model may be standardised.)

Further the following course of action is suggested to ensure 'variety rationalisation' to a greater extent :—

(i) Having acquired intensive experience over a period of 15 years or so, by and large the design of at least 10 classes of vehicles i.e. from class 'B' to class 'K' may be indigenously developed, tried out and produced with major changes in primemovers, chassis, suspension, axle and wheels (four wheelers only) transmission, electrical system of vehicles. The anticipated changes are mentioned in Table I of appendix 'A' to this paper.

(ii) Basically engine characteristics, like cylinder bores/stroke, speed (RPM), valve, size and configuration of piston and piston rings, gudgeon pins, connecting rods, crank shaft, small and big bearings, lubrication and cooling ducts etc to be standardised in the same class of automobiles.

(iii) Fuel system in the case of diesel vehicles in the same class to be stream lined with reference to specification parameters.

(a) Fuel tank and pipe	—Size capacity and location.
(b) Fuel pump	—RPM of shaft and delivery pressure.
(c) Fuel filters	—To conform to 15-3169-1965 for mechanical tightness, Through flow rate test and Filtering efficiency.
(d) Fuel Injection Pump (In line type)	—Rate of flow and RPM, direction of rotation, Location of pump in relation to cam-shaft of engine.
(e) Injectors	—Breaking pressure.
(f) Governors	—Centrifugal Governors with same sensitivity.
(g) Cooling system	—Size and rate of circulation in Radiators to be uniform for the same class of vehicle.
(h) Lubrication	—Oil Pumps to be designed in relation to the area of bearings i.e. oil pressure to be in the range of 3 to 5 Kgs/CM2 for 3 ton vehicle.
(i) Transmission Gear (Heavy vehicles)	—Main gear box and auxilliary gear box to contain standard gears to match speed ratios warranted for steep road gradient 1 in 10. Provision for use of low gears in Cross country to be made. Transmission gears in Cars to be limited to only four speed forward and one speed reverse.

(iv) Wheel base and track width of four wheelers/ six wheelers to be uniform in the same class of automobiles to facilitate use same propeller shaft, spider bearings, differential gears, wheel disc and its connected items.

(v) It is imperative that the steering geometry has to be complied with by selection of suitable steering gears, tie rods and other linkages having appropriate relation to the connected items and achievement of satisfactory steering results. Also the steering mechanism existing

Table 1

Appendix 'A'

Sl. No.	Nomenclature	Make and type of Engine	Bore	Stroke	Rated RPM	Max HP	Fuel consumption	Remarks
1.	Truck transporters 3 tons 4 × 2 i.e. class 'C'	OM-312 Six cylinder Diesel Engine	90 mm	120 mm	3000	110	6.7 KM per litre	Acceptable.
2	Truck transporters 3 tons 4 × 4 i.e. class 'C'	-do-	-do-	-do-	-do-	-do-	3.68 KM per litre	Suggested to be standardised.
3.	Buses i.e. Class 'D'	-do-	-do-	-do-	-do-	-do-	6.7 KM per litre	
4.	Jeeps Class 'E'	Four cylinder Petrol Engine	79.375 mm	111.125 mm	4000	70	5.8 KM per litre	Bore size not conforming to IS standard 3511-1966
5.	Car 5 Cwt Nissan Petrol i.e. Class 'E'	Six cylinder Petrol Engine	85.7 mm	114.3 mm	3400	125	5.59 KM per litre	-do-
6.	Truck 1 ton 4 × 4 GS-D4W-73N Nissan	-do-	-do-	-do-	-do-	-do-	4.42 KM per litre	Proposed in class 'F' to be redesigned.
7.	Truck 1/2 ton 4 × 4 GS i.e. Class 'F'	Four cylinder Diesel Engine indigenously to be developed	Existing size non standard	Existing size non standard	Around 3500 RPM	Approx 80 to 90 HP	To be arrived at after trials	to conform to ISI 3511-1966
8.	Car Ambassador i.e. class 'G'	Four cylinder Petrol Engine	-do-	-do-	4000	45HP	-do-	-do-
9.	Two wheelers i.e. class 'J' vehicles	Single cylinder Petrol Engine	70 mm	90 mm	5600 RPM	18	28-30 KM per litre	-do-

Notes :— (a) Sri No. 3 and 4 engine have to be re-designed to conform them to 4 cylinder petrol engine in one common group to achieve BHP-60 at rated RPM of 3500

(b) Bore/stroke of Engine at serial No. 5 to be oriented to conform to IS standard 3511-1966 for ensuring end use parameters.

in Benz vehicles to be made common to class 'B' 'C' and 'D' vehicles and among Cars the type in 'Fiat' is an acceptable one.

(vi) Brake system fitted in automobiles are listed below :

(a) Pneumatic air brakes—Heavy vehicles.

(b) Hydraulic assisted air brakes —Heavy vehicle like Benz.

(c) Air Brake only —Heavy vehicles like Shaktiman and Ley-Land only.

(d) Hydraulie brakes —Cars and Jeeps etc.

(e) Mechanical brakes —2 wheelers & others.

Suggested that present hydraulic brakes be retained in Cars and pneumatic air brakes be suitably applicable to Truck transporters and Buses of 3 ton capacity and above. M/s Sundaram Clay-ton (Pioneer for Brakes) are to be associated with ISI for rationalisation of

pneumatic air brakes to render interchangeability in the brake system for the same class of vehicles. Similarly mechanical brakes for the same class of two wheelers be made common to achieve uniformity.

(vii) Specifications in respect of starter motor, dynamo, cut-out, fan belts, pulley, electrical wiring, bulbs, head lamps, tail lamps, reflectors also be codified in the same class of vehicles.

Anticipated advantages by implementation

(a) Adoption of indigenous designs and development leads to a self generation of reliable automobiles.

(b) Optimum utilisation of brake horse power in class 'G' to 'X' by variety rationalisation.

(c) By derating an engine to meet just the end requirements redundant fuel consumption is saved.

e.g. Utilisation of Nissan Engine fitted in Nissan 1 ton service vehicle is not warranted for fitment in 'Nissan Jonga' as examined from end use. Since Nissan Jonga and Nissan Petrol is a passenger vehicle except the ones on specific role.

(d) The above analogy holds good in all classes of vehicles (from 'G' to 'K') and petrol to the tune of lakhs of litres can be saved specially when petrol scarcity is there.

(e) Fuel system and connected items may be rationalised in the same class of products and thereby interchangeability and tech simplification achieved.

(f) Transmission group and its connected items can be streamlined by establishing same wheel base and track in a particular class of vehicle.

(g) Variations in brake system may be circumvented and uniform sub assemblies be selected in the same class of vehicle.

(h) Similar applications are possible in electrical system as well.

(j) Inventory control anticipated is quite considerable and savings in space & manpower results in financial benefits to the level of lakhs of Rupees.

Conclusion

Summing up the contents, it is seen that there is a dire necessity to establish a 'Standardisation Bureau' for convening various committees at different levels to review 'variety rationalisation' in the field of automobiles and examine the acceptable norms with respect to main assemblies and sub systems. Eventually the producers and users are to be educated on the importance of introduction of standard class of products for achievement of the goal. Alongside the confidence of the parliament has to be won for enforcement of relevant articles in the constitution.

Productivity
1984, XXV, 3, 379-383

EXECUTIVE READINGS

Personnel Management
Dr. C.B. Mamoria

Published by :
Himalaya Publishing House, New Delhi
Price : Rs. 90/-
pp. 871

Reviewed by :
Shri D.P. Upadhyay,
Director,
NPC, Delhi

The present title is perhaps the most comprehensive on the subject published till date by any Indian author. It may disappoint those who expect originality or analytical approach but it will fully satisfy those readers who want lots of information on all aspects of personnel functions at one place. The readers may think, "could the same material have not been given in lesser number of pages ?" Surely it was possible, had the author been a little careful in dropping some less important or insignificant points which he might have jotted in his notes prepared earlier. It is true that the book is primarily written for students but gone are the days when they were expected to score more marks by cramming and reproducing quotations. The modern trend is to evaluate the understanding of a concept or an approval and its analytical discussion.

Let us take section-I and its first chapter devoted to the importance, definition, objectives of personnel management besides qualities quantities of personnel managers, terminology etc. The analysis of definition contains fifteen quotations. These quotations instead of clarifying the scope of personnel management create confusion. While quotations from standard books and references are strengths of this title, the reader gets jerks in the study of the subject because of too many quotations. It would be better if the author is selective when the second edition is published. The first section itself has five chapters. The chapter dealing with functions of personnel management (chapter-II) contains all the functions but it has become too long due to reproduction or presentation of summary of area classification of several other authors both foreign and Indian. Naturally listing of same functions again and again could not be avoided. A better approach could have been to select from each authors classification only that part which was an addition to the areas discussed in the main text of the chapter.

Section-II deals with importance of man-power planning recruitment and selection process performance appraisal, training other aspects of personnel management. The use of forms, figures for illustrations besides parameters of evaluation etc. are given in a very logical and thorough manner. This section is more useful for practicing managers. In fact this is the best chapter of this book which contains lots of information in a very planned way. The author should have given forms of some leading companies of India as illustration. While the text part of this chapter is superior than other books written by Indian authors, one may feel that something was missing due to non-reproduction of such forms.

Rustain S. Davar's book on this subject is having such references which add to its authenticity besides giving opportunity for a comparative study.

Section-III is devoted to wage-administration including job-evaluation and incentives. Section-IV covers groups dynamics, employee needs, problems related to grievances, discipline, communication etc. Section-VI covers matters related to health and safety, fringe benefits etc. Section VI discussed industrial relations, workers participation in management.

No doubt the book is sufficiently detailed and is supported by a large number of tables, charts, diagrams and appendices. Though meant primarily for students, it is useful for practicing managers also. Its greatest strength is that besides providing conceptual framework, it refers to practical implications in each area.

Bible of Management
Parkinson C.N. & Rustomji M.K.

Published by :
I.B.H. Publ. Co. Bombay
Edition : 1983
Price : Rs. 25
pp. 88

Reviewed by :
Dr (Mrs) Poornima Mathur
Head, Department of Humanities & Social Sciences
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The book renders a pragmatic set of points for every aspect of management of organisations. It is a very useful asset to persons who are trying to put organizational processes such as communication, decision making and control to reality. The need for understanding good management is very well brought out by every piece of idea in the chapters. The need thus created sustains itself throughout—almost breathlessly from the beginning to the end of the book. Ideas of the theorists, such as Macdonald, Koontz and O'Donnell, Drucker, Humble etc. have been very lucidly put across to the layman. Chapters V (The Structure of Organisatton) VII (Management by Objectives), VIII (The Use of Time), XII (Cost Control), and XIV (Human Relations) are particularly effective in counting the tips to become an effective manager. Lastly, the importance given to future planning is a good epilogue for the book to conclude. The authors still keep the user on the toe by pointing out the irrelevance of delay in decision making, extrapolating for the future from the past decisions, concentrating on opportunities to plan and act having a style of solving problems on one's own, acting out with time-appropriateness, contribution of one's own unit towards betterment and improvement of the organisation which are real challenges to the user in order to be an effective manager. The reader while consolidating the above challenges is made to think of managing the new types of organisations emerging in areas like world-wide transportation, customer-service companies based on computers, non-business organisations like hospitals, government agencies, universities armed forces etc. (p. 23) which cannot be really decentralized and are too big to be managed centrally. The book becomes a significant trail behind in the mind of the reader.

A word about the illustrations in the book. The book has many illustrations, bringing the points home which every specific chapter portrays.

The authors need to be congratulated for the precise but excellent presentation of ideas to spread the message of good management to both in formal and informal settings and people involved there in.

Small Industry—The Challenge of Eightees
Dr. Ram K. Vepa

Published by :
Vikas Publishing House Pvt. Ltd ,
New Delhi
Year of Publication : 1983
Price : Rs. 150/-
pp. 356

Reviewed by :
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Small is beautiful—was the message of Schumacher. Small works—is the finding of the 1983 best selling book of Peters and Waterman. Small is essential—is the emphasis of this book. Small

industry, according to Dr. Vepa, is imperative for solving the problem of increasing number of unemployed. In his opinion the development of small industry is the development of small people. The term industry in the book has been used with an expanded connotation. It includes not only manufacturing but also services and business in sectors like handlooms, handicrafts, dairying, poultry & fishery.

2. The book has three parts. Part I deals with Indian experience and highlights the view that major benefits of credit, technology, marketing and special development programmes for backward areas, have been availed by enterprises in more developed areas. This has led to the dominance of some parts over others.

2.1 For instance the "entire" banking system according to the author is "anti rural and anti small man". In this context it is relevant to note the observation of the World Bank Report (1972). "Any organization controlling the flow of a scarce commodity is subject to criticism". According to Dr. Vepa the application of the sophisticated techniques of investment appraisal like discounted cash flow, market survey, in case of small enterprises, are often a waste of time. To him the borrower's creditworthiness is fundamental. The author has no specific suggestions on the question how to assess it. The question of appropriate methodology of investment appraisal for small enterprises is important in view of the fact that by December 1980 a sum of Rs. 2064 crores of banks & financial institutions was locked up in the sick units. Dr. Vepa has suggested that an Apex Financial Institution for the tiny and decentralised sector may be created. This will ensure a large flow of credit. Reader may ponder whether an additional financial institution will be the solution to the problem.

2.2 On technology the author's suggestion is to have a well—formulated national policy. It should provide impetus to rural development. Perhaps the author finalised the manuscript of his book before the announcement of technology policy of Government of India. According to Dr. Vepa, micro-hydel units on Chinese model, biogas plants and wind mills have significant role to play in rural development. The imported technology should be integrated into the blood stream of indigenous technology. This appears to be a motherhood statement. It is difficult to determine the mix of the two.

2.3 The enterpreneurship is considered vital if small industry is to play an important role in the growth of backward areas. Along with the various measures suggested by the author to improve entrepreneurship, he may consider introduction of business management in the syllabus of higher secondary education. This is likely to help in development of enterpreneurial skills.

3. Despite various inadequacies the author recalls the important role played by the small industry in economic scenerio of India.

4. Part II of the book gives an account of small industry in Japan & China. The author has also given a synoptic description of small industry in more than 35 countries of Asia, Africa and West. A reader is inclined to hold that the author with his rich experience of being Development Commissioner for Small Industries in New Delhi, and UNIDO Advisor on Small Industry to Sri Lanka and currently at Jakarta, could do greater justice in analysing the development of small industry abroad in Part II of his book, had he confined the discussion to a few countries. The broad and statistical description of the salient features is a poor substitute to indepth study.

5. Part III deals with the perspectives & problems of small industry. No one will dispute the conclusion drawn by the author on the need to have a proper "man & machine" mix and to lay emphasis on the object of modern scientific development in the words of Prof. Nobert Wiener as to make "human use of human beings". Views may, however, differ on what that mix is to be in competitive world in the years to come. Readers will also not differ from the author that the small industry has an important role to play to bring the benefits of industrialisation to rural and semi-urban areas. But he may find difficult to accept his conclusion"—in the next 20 years as many as 50 million jobs may have to be created outside the agricultural sector and this magnitude of job creation will be impossible in the framework of conventional industrial growth. Those who plead for emphasis on heavy industry need to realise that

the creation of even a single job in that sector is becoming increasingly expensive. It costs as much as Rs. 1,00,000 for one job and to create 50 million jobs would take an astronomical sum of money which the country can hardly afford". Apart from the questionable data one may doubt the justification of mechanical projections of past trends. We are living in the age of discontinuity. Technology is fast changing. The economic growth in advanced countries can be attributed to a very great extent to the development & assimilation of high skill technology. Successful corporations in these countries operate with sophisticated technology. Europe's Airbus competes with Americans Boeing Co. Italian robots developed at Fiat are used by automakers around the world. French Aviane rocket may take lucrative satellite launching business. Britain's Harrier jet and West Germany's Leopard tank are world leaders. Japan deals in multibillion dollar high technology field. Such large corporations have, however, realised the importance of small units within them from man management & efficiency point of views. Nicholas Vitorovich a senior member of the Mc Kinsey Consultancy's Milan office rightly pointed out—"Managers have rediscovered that there is beauty in smallness and incalculable benefits". But big remains small by spreading new or expanded activities into new divisions. In this lies the secret of efficient & effective working of big corporations.

6. The historical reality is that both big and small enterprises contribute significantly to the national growth. A judicious mix of the two is a head scratching exercise. This book makes a good contribution by emphasising the role of small industry for economic support to small people and weaker sections of our society and by establishing a need for a comprehensive strategy of growth of small industry.

Theory of Evolution of Accounting Ideas
Man Chand Maloo

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pp : 200

Reviewed by :
Ms. M. Vinaya
American Express Ltd.
New Delhi

'Business Management' is a public trust. It must conduct itself so that it will have the right to ask for public confidence ! In this context, financial accounting and reporting assume a role of considerable importance. For many a man, who look back to know, how this financial accounting and reporting, have evolved over the years, the present study by Maloo, would be of interest, though the focus of this study is confined to United States of America only. Accounting, like any other man invented phenomenon, has progressed according to the needs as felt by man and by environmental pressures : social, political and economic.

This book, presents the overall growth of accounting in the form of the Hegelian Dialectical Process of Thesis, antithesis and synthesis and focusses on changes of practices in certain areas of accounting such as : Replacement Cost depreciation, direct costing, research and development costs, investment tax credit, long term leases, & pension costs, and presents a model, where a initiator first proposes a change which finds both proponents and opponents because of financial consequences associated with the change. The initiators, as identified by the author in areas like Replacement cost depreciation and Direct costing are those nearest to the process like managers and accounting practitioners who are aware of the voids in accounting the reporting and who would want accounting to be of assistance in decision making, in as inexpensive and quick a manner as possible. The author identifies the objectives of disclosure, uniformity and internal consistency as being the factors sought to achieve comparability among financial statements, which gave a sense of direction to the growth of accounting while corporate managers and academicians played an aggressive role in proposing changes, except in areas like investment tax credit, where the U.S. government was the initiator, with an intention to pace up the modernisation, to win the 'race to Moon', bankers, trade associations and national credit guarantors associations, often opposed radical changes, on the plea that any

changes in accounting method, would confuse the investment decisions.

The author concludes that state controls have reduced the scope of privately proposed accounting ideas and that the progress in accounting is not in keeping with the rapidly changing environment. For instance Business Week's survey of some 300 annual reports shows that one of the problems with replacement cost data is that they do not take into account any cost savings that might arise when a company replaces order equipment with more modern technology. There is scope for taking that into account.

However the book does not throw much light on the role of opinion leaders, causes of peaks and troughs in accounting changes, diffusion of change internationally, influence of political, cultural social factors in the environment. In todays shrinking world, an international comparative study in the context may be very apt.

The book reads like a doctoral dissertation. Very academic in content. Price unduly high.

Theory Z
Ouchi G. William

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pp : 244

Reviewed by
Dr (MS) Mani K. Madala
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New Delhi

Japan had drawn the attention of the world, by recording a very high level of Productivity, when Productivity levels every where else in the world have been declining. In the past two decades, the western Corporations have closely observed the rising supremacy of their Japanese counterparts, but never thought they can emulate, the Japanese techniques and management practices, which they presumed to be unique and specific to Japan. Ouchi thought differently and in this revolutionary book, he outlines exactly why, what and how we can learn from the Japanese success. Ouchi G. William who coined the term 'Theory Z' has spent years researching and examining the major corporations in Japan. He has also worked with many Fortune 500 companies in the United States and has consulted with all those who have adopted 'Theory Z' style of management.

The book in the first part discusses the essence of Japanese management philosophy and practice. The author then identifies a set of practices, policies and procedures which do lead to a better job satisfaction and therefore better Productivity. Some of practices, identified by him, are long term employment, Career paths wandering around functions, a climate which allows the employees to pursue projects which the employees believe would succeed, a consensual style of decision making—in other words, all those practices which make the people in the organisation 'wholistic'-'wholistic' is therefore the key word.

Based on his experiences the author names several companies in the western world, who have the above mentioned practices and been reaping the benefits there of. He explodes the myth of some management practices being 'culture specific', advocates that every organisation can take to 'theory z philosophy' with proper preparation. To get to this goal he gives a thirteen stepped approach which sounds easy but is difficult to practice, the important among which are slow evaluation and promotion of personnel, broader career path development, which in a segmented hierarchical kind of set up like ours would meet with a lot of resistance.

Presentation of a number of case studies, makes the book an interesting reading. This is a paper back edition.

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Select Bibliography : Measures of Productivity

BHOOSHAN LAL
RATNA KAUSHIK

There has been renewed emphasis in the industry on knowing whether we are going in the direction in which we had wanted to go and how far have we gone in that direction. It becomes necessary to measure our performance to increase productivity. Measuring productivity is a very complex process as it is a result of several tangible and intangible factors. This bibliography on 'Measures of Productivity' presents the most recent references in this area. We hope the readers will find this useful.

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Letter from the Editer-in-Chief

Dear Reader,

Our great heritage goes back to Indo-Gangetic civilization which was nurtured for centuries through the development of agriculture. In fact, the word "culture" was for the first time associated with agriculture. Even today, it constitutes the largest sector of economic activity and rightly it is the most important component of country's overall economy. It provides food and fibres and life sustenance to the millions. It provides raw materials to a large number of industries, such as, cotton textiles, sugar, Jute, tobacco, rubber etc. It offers maximum employment to the bulk of our population. The decennial census report also states that over 70 per cent of the country's working population is engaged in agriculture.

Despite limitation of land, our agriculture resources are vast and rich. For major part of the year, there is abundant sunlight and the climate supports plant growth round the year. The water resources of the country are substantial. Even the potential for animal husbandry and acqua-culture is very large. We have a coast line with an exclusive economic zone and the sea surface available accounts for nearly 40% of the size of our oil resource. In a way, the ecological diversity has helped in the cultivation of wide ranging crops, both tropical and temperate and the plant resources which include the multitude of crops and a variety of forest vegetation.

The agriculture scene in India until '50s. continued to be traditional reflecting a low productivity and poor economic returns. The crop yield continued to be lower and the food production remained far below the required level. In the area of live stock, fisheries and forest produce as well, their performance did not present a bright picture. And, yet it did not take a long time for the country to come out of this difficult situation which was accentuated by the high rate of population growth in the country. As against food grains production of 58 million tonnes in the early fifties, during 1983-84 we have touched an all time record of 150 million tonnes. This justifies the fact that given the will and the determination, our capability during the last 35 years in agriculture has exceeded the stipulated targets and we are well set in our march for a faster growth. We can, therefore, confidently say that the food grains target for the Sixth Five-Year Plan is well within our reach.

The population projection beyond 2000 AD continues to pose a positive threat to the expanding requirements which will have to be met from the agriculture sector. There is short-fall in the production of pulses and edible oils which are equally essential. We have, therefore, to provide for the requirements of food and fibre for the vast expanding population. As per the estimates of the National Commission on Agriculture, it is estimated that by 2000 AD we shall require a food production of 205-225 million tonnes, 24-30 million tonnes of sugar and gur, 8-10 million tonnes of vegetable oils, 10-17 million bales of raw cotton, 49-64 million tonnes of milk etc. In addition, agriculture will also have to provide opportunities for gainful employment to the bulk of rural population.

A major challenge of agriculture in the coming year and particularly during the 7th Plan period will be the availability of capital required for its development and its potentialities of generating surplus for national economic development. To overcome these imperatives, the following requirements among others may be necessary :—

(i) Modernising agriculture through application of new technologies for increasing productivity by adhering to crop rotation and application of scientific production methods.

(ii) Rational management of agriculture on scientific lines with greater emphasis on the factors involved in production, distribution and consumption.

(iii) Laying greater emphasis on post-harvest operation, such as, transport, storage handling and preservation.

(iv) Ensuring that a higher social status is accorded to agriculture and the farming community.

Our public policies towards agriculture have to change radically. While small farmers put in their best in times of fall in production, they are the worst-hit having no financial basis to bear it, and even when there is a bumper crop, they are losers for the market price falling steeply. This is accentuated since they do not have the holding capacity. Also, our operating systems do not provide relief at the appropriate time and heightens their suffering.

Despite difficulties, we are already on the pathway to progress. The traditional agriculture is changing into a modern system. This is bound to bring in newer challenges. Every action leads to reactions, some favourable and some unfavourable. The unfavourable ones can be guarded by continuous monitoring of problems and taking appropriate actions to avoid the side effects. We have, therefore, to steer through the future with courage, caution and care to solve the twin problem of poverty and unemployment. With the given natural resources, strong leadership, progressive outlook and recognition of the role of farmers in the national economy, our India of to-morrow can emerge as an 'agricultural power' and beacon the way to the rest of the world for development of agriculture on a massive scale. The beginning process of culture can become the dominating theme of sustained progress, growth and prosperity to mankind.

(A.N. SAXENA)

January–March 1985

PRODUCTIVITY

SPECIAL SECTION : AGRICULTURAL PRODUCTIVITY

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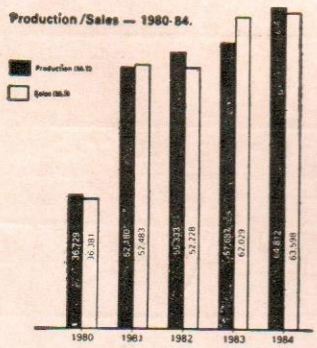

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