l Issue on Measurement of Productivity

PRODUCTIVITY

JOURNAL OF NPC

NATIONAL PRODUCTIVITY COUNCIL, INDIA

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NATIONAL PRODUCTIVITY COUNCIL

The National Productivity Council is an autonomous organisation registered as a Society. Representatives of Government, employers, workers and various other interests participate in its working. Established in 1958, the Council conducts its activities in collaboration with institutions and organisations interested in the Productivity drive. 44 Local Productivity Councils have been established practically all over the country and work as the spearhead of the productivity movement.

The purpose of NPC is to stimulate productivity consciousness in the country and to provide services with a view to maximising the utilisation of available resources of men, machines, materials and power; to wage war against waste; to help secure for the people of the country a better and higher standard of living. To this end, NPC collects and disseminates information about techniques and procedures of productivity. In collaboration with Local Productivity Councils and various institutions and organisations it organises and conducts training programmes for various levels of management in the subjects of productivity. It has also organised an Advisory Service for industries to facilitate the introduction of productivity techniques.

NPC publications include pamphlets, leaflets and Reports of Productivity Teams. NPC utilises audio-visual media of films, radio and exhibitions for propagating the concept and techniques of productivity. Through these media NPC seeks to carry the message of productivity and to create the appropriate climate for increasing national productivity. This Journal is an effort in the same direction.

The Journal bears a nominal price of Rs. 2.00 per issue and is available at all NPC offices. Annual subscription (Rs. 12.00 to be sent by cheque in favour of National Productivity Council, New Delhi) is inclusive of postage! Subscription for three years, however, can be paid at the concessional rate of Rs. 32.00.

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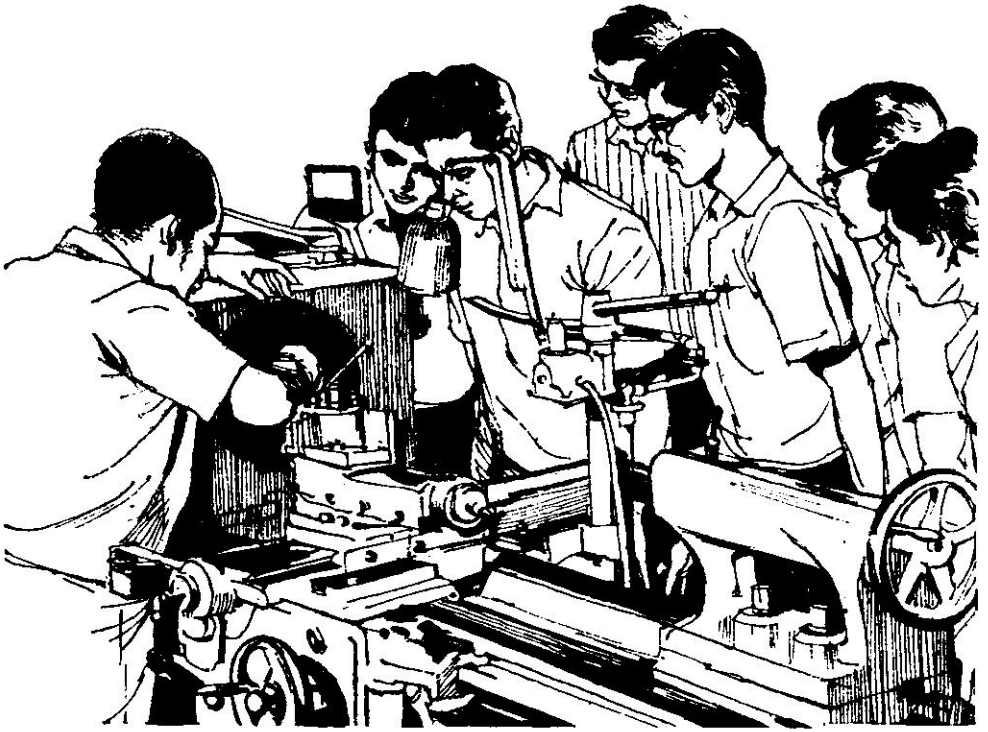

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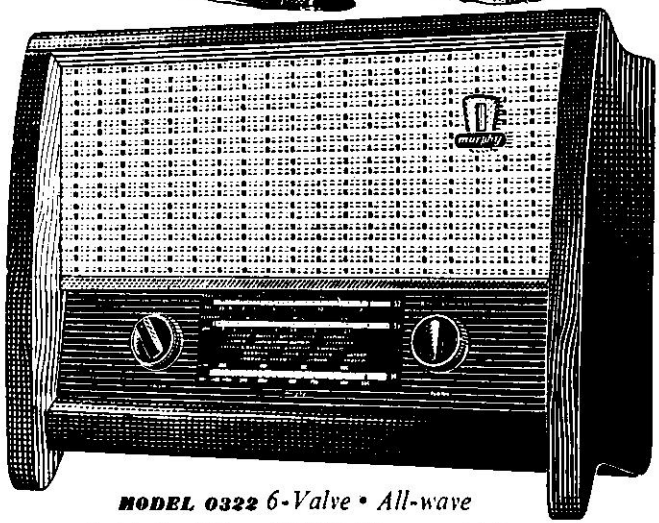

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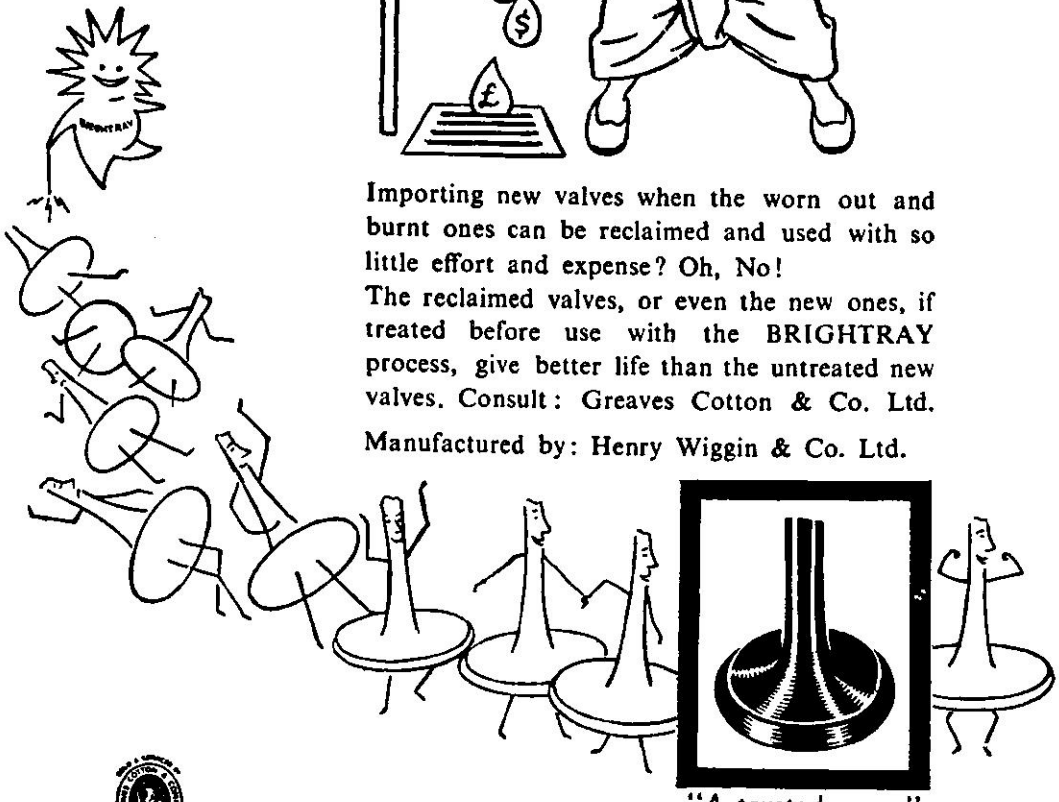

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NATIONAL PRODUCTIVITY COUNCIL JOURNAL

Vol 3 No 1 **PRODUCTIVITY** **Nov—Dec 1961**

The Dynamics of Productivity

THIS THIRD SPECIAL ISSUE OF THE NPC *Productivity* JOURNAL, DEVOTED largely to the theory and practice of the measurement of productivity, is concerned more with its dynamics than with purely static analysis, for in the economics of productivity, to use the famous phrase of Dean Swift, *two and two instead of making four might well make zero or at the limit, infinity.* The introduction of one low productivity factor such as poor management, for instance, into a complex industrial establishment might well bring a whole concern to its own level of low productivity. On the other hand, a high productivity factor, again, such as an active and farsighted management, might drive a whole stream of tendency throughout the entire mechanism of productive relations so as to raise the efficiency of the whole system to a parity of its own performance. *Well thought out incentives would, in all human probability, have a transforming effect on the whole economy.* A 25 per cent incentive might well result into a 100 per cent increase in productivity through a marked reduction in per unit overhead costs, through improved materials and machine utilisation, avoidance of the terrific waste that characterizes the whole industrial economy of this country, above all, a mobilisation of the latent abilities and skills of men and women, who work the industrial system.[1] It is the measurement of these dynamic aspects of Productivity that NPC is interested in and to which the Planning Commission has drawn attention in its final draft of the Third Plan: "The rate at which average levels of productivity rise in different sectors is a true measure of the pace and quality of the advance achieved...*the only enduring basis for the strength and dynamism of the economy is a rising level of productivity...*"[2]

In fact, the classic purpose of productivity measurement is to ascertain the rate of economic growth over time of a particular society or country. That is why *Productivity of Labour*—and not the distribution of the fruits of industry—was the centre of the piece in classical political economy. The postwar direction of economic thought towards analysis of The Problems of Growth and Development has led to a resurgence of interest into the Dynamics of Productivity, as evidenced by the work of Dr Laszlo Rostas, upon whom the contributors to this Volume have drawn rather freely.

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1. *"As a rule, men habitually use only a small part of the powers which they actually possess."* William James
2. The Third Five Year Plan, Planning Commission, Government of India, 1961, p. 650, italics ours.

The Mathematics of Measurement

It is against this dynamic background of the needs of development that the mechanics of measurement have to be considered; for the level of productivity is not the mere summation of the productivities of the various factors of production that enter the industrial equation. It is *more the interaction of a variety of attitudes, personal and cultural, within the complex of a given social situation that determines the level of productivity.* Quite a few of the able contributors to this Special Issue have discussed the mathematics of measurement[3]: the problems of price deflation, of the heterogeneity of the outputs and inputs, the complexity of the capital concept and the many difficulties that harass, particularly, the purist among the theoreticians.

The Purist Approach

The Purist Approach to Productivity Measurement reaches the limit of finesse in an excellent article on Aspects of Productivity Measurement by Irving H. Siegel of the US President's Council of Economic Advisors, who insists on *upgrading the sophistication of makers and users of productivity indexes,* who dallies with the luxury of constructing an ideal productivity index and feels not a little depressed by *'the attendant intellectual responsibility'* and the confusion caused by the lack of accordance between pre-operational and actual operational concepts. *The need for practicality in the affairs of men* has, however, been an overriding factor; and even this purist among the theoreticians, while insisting on the conventional character of index numbers "assumes them to be *worth constructing and using nevertheless*...All these measures are *conceptually satisfactory in the absence of a closer specification of purpose or* use." Nevertheless the author "insists that *a certain purism is desirable*[4] in appraising the appropriateness of techniques employed and applications made."

The Conceptual Framework[5]

Between a purely mechanistic approach and a rigidly purist analysis, we have to find a balanced framework for analysis. The

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3. Productivity economists, particularly in this underdeveloped country, might benefit greatly by bearing in mind Keynes's reference (page 275 of the General Theory) to the "...pitfalls of a pseudo-mathematical method, which can make no progress except by making everything a function of a single variable and assuming that all the partial differentials vanish..."

4. Italics ours.

5. "...philosophical and conceptual clarity is essential in this field, as elsewhere, but it will come only as a result of decades of continuous intellectual fermentation..." (extract from leading article in NPC PRODUCTIVITY Journal volume 1, No. 3, p. 1). Towards this end, quite a number of articles have appeared in this Journal on the Concept and Measurement of Productivity: (i) Concept and Measurement of Productivity by Dr BB Lall of the Allahabad University, volume 1 no. 4, p. 236 (ii) Productivity: Its Concept and Measurement by Dr KS Sangha, Visiting Professor, Department of Economics, College of William and Mary, Norfolk, Virginia USA volume I No. 5 p. 343 (iii) The Concept of Productivity by Dr GC Beri, volume II No. 1, p. 50 etc.

mechanics of measurement have therefore been discussed in this issue of the Journal in some considerable detail against the whole background of the conceptual framework within which the theory and practice of productivity have been discussed for many years. As we have yet to achieve a measure of maturity in our productivity statistics and ideas, we have here drawn rather heavily upon the extensive work done in this direction by the ILO (the pioneer in economic analysis of productivity) the EPA[6] and a number of international authorities on productivity measurement (Rostas, Seymour Melman of Columbia University and others). A number of our own writers Dr R Balakrishna of the Madras University, now of the Tariff Commission, Dr MM Mehta (ILO manpower expert) Dr MC Munshi of the Bangalore Institute of Science, Dr BB Lal of the Allahabad University, the young Dr GC Beri of Vallabh Vidyanagar and quite a number of others—have done remarkable work in productivity measurement in this country. Most of them have contributed articles to the special issue; or their standard works have been quoted in respect of what may be considered as significant contribution to the development of productivity thought and statistical measurement of productivity.[7]

Essentiality of Work Measurement

We have, however, to confess that in the actual measurement of productivity in this country, we are treading a more or less virgin ground, despite *substantial* contributions by distinguished academicians, referred to in the preceding paragraph. The reasons for this are partly fundamental and partly historical. Large scale mechanized industry, taking the country by and large, is a matter of recent development in this country; and the science of work measurement has hardly been introduced except in a few concerns, which enjoy the advantages of modern management. Unless we measure work on the shop floor and establish (fair and reasonable) standards against which actual work performance may be measured, we would be far from accomplishing even the crude measures of labour productivity at any satisfactory level of achievement. Work measurement in its turn is a part of work study;[8] and this we have hardly undertaken on any scale. This again leads us on to the dynamics of productivity for those who have applied work study techniques, have reported *startling increases in productivity, consequent on work simplification.* ..

Essays in Measurement

Nevertheless, on the basis of historical standards, considerable pioneering work has been done in this country to which references have

6. European Productivity Agency's Productivity Measurement Review

7. Every effort has been made to acknowledge borrowing operations either directly or in an omnibus announcement at the end of this Journal.

8. **The next special issue of the Journal will be on Work Study, including methods study and improvement, work measurement etc. The editor invites competent and experienced persons to contribute their best in the form of short articles (1200 to 2500 words) embodying their experience through study, teaching or actual application of work study techniques on the shop floor or in the administration of business or government offices. Case studies and digests of best literature on the subject would be particularly welcome.**

been made in the articles published in this special issue. In addition, a number of competent persons have at the special request of the editor contributed their essays in measurement: these cover a number of special studies in the measurement of productivity in iron and steel, coal, cement, jute etc. Sreelekha Basu[9] has worked out labour productivity indices for as many as 11 industries, besides a general index. NPC senior economist, Sri G K Nayar, has constructed index numbers of industrial productivity for six major industries: cotton and jute textiles, sugar, cement, vegetable oils and paper, besides an all-India index, weighted according to investment.[10]

Postwar Productivity

The conclusion that there has taken place during the postwar period, particularly since the start of *Planning* in 1951, a substantial increase in industrial productivity is amply supported by the overall statistics of output and employment. The latest index of industrial production shows an increase of 84 per cent since 1951. In about the same period, employment in registered factories has gone up from 2.5 to 3.6 million, that is, an increase of 44 per cent. It is true that these statistics are not exactly coextensive but there is every reason to believe that the magnitudes involved would be almost identical. From a broad national standpoint, an increase, since 1950-51, in *per capita* income of 16 per cent at constant (1960-61) prices, goes to support the hypothesis of a substantial increase in productivity, particularly in the industrial sector. Not considering the increase in population, the real increase in national income again at constant prices, has been of the order of over 40 per cent over the last decade.[11] General increases in industrial productivity are also evident from the breakup of industrial statistics. While employment in coal mining has since 1951 increased by not more than 10 per cent, the coal mining output index shows an increase uptodate of 80 per cent. It would appear from available statistics that this *increase in productivity is continuous*, for the latest statistics show that while the productivity of workers employed in coal mines was 457 kilograms per manshift in early 1950, it was 466 kilograms at the same time this year.

The Planning Commission in its survey of *Ten Years of Planning* has cited a large variety of statistics showing massive increases in output in a variety of lines: 150 per cent in steel ingots, 400 per cent in aluminium, over 1500 per cent in graded machine tools, 267 per cent in sulphuric acid etc. These increases in output are typical and would of course be accounted for by a number of factors: increased employment, higher labour efficiency, increase in industrial investment, and above all the adoption of productivity techniques. There is, however, ample theoretical support for presuming that "*over time, there is an association between rapid growth in total output of particular industries and rapid increases in producti-*

9. AICC Economic Review, August 7, 1961.

10. Printed in this issue.

11. Planning Commission's Report on the Third Five Year Plan, p. 35

vity...[12] The causal factors here are obviously interrelated...increases in total production stimulate productivity both by enabling increased economies of scale and, as a result of an increase in the proportion of new plants, enable more use to be made of the most modern equipment and technology..."

Mechanisation and Productivity

It has often been argued—and the argument may with good reason be repeated in respect of postwar developments in the Indian economy—that the large increases in output and productivity may be attributed to mechanization. Probably the statistics presented in the piece published by the Association of Indian Trade and Industry and printed in this volume (Productivity in Indian Cement) would support some such conclusion. Seymour Melman in his famous thesis on the *Dynamic Factors in Industrial Productivity* has also emphasised the same conclusion : *"The dramatic rise of industrial productivity over the last half century is traceable primarily to transformations in the technique of production*...They are the source of the large and lasting productivity gains, for the character of production equipment and allied methods governs the potential output towards which other factors such as organisation indeed contribute..."

This raises important theoretical issues but the practical conclusion would be along the lines arrived at as a result of the joint comparative study of the national output and productivity of the UK and USA undertaken by the OEEC and the Department of Applied Economics of the University of Cambridge: "...although output per worker in the USA is rather more than 2½ times that of the UK...it would be quite incorrect to argue from this that the higher productivity of American industry is attributable predominantly to a larger capital input. The important factor is...that *owing to the various technological and natural resource differences, the combination of capital and labour employed in the USA has a higher productivity than the combination of capital and labour used in the UK*"[13] It is also commonsense to presume that when workers are operating more or superior machines, the worker productivity goes up. at least, equally well.

A great deal of theoretical controversy rages round labour as the measure of productivity. This has been discussed at great length and from various points of view in the body of this Journal. Probably the judgment of Dr. R Balkrishna would be accepted as the most balanced : "...*physical output in relation to labour input is the norm of measurement* ...Though the indices thus derived are based on labour, they do not measure merely labour efficiency. It is actually a measure of efficiency in general, reckoned in terms of one specific factor....any factor affecting

12. "...in a less developed country, the prices of capital equipment are usually relatively high, so that the capital-output ratio would be higher in its own price structure than in that of a more highly developed country." A Comparison of National Output & Productivity of the UK and the USA, Deborah Paige and Gottfried Bombach, Joint Study by OEEC and Department of Applied Economics, Cambridge University, Paris 1959, footnote 1, p. 69, italics ours

13. Ibid

output of labour may have an influence on labour productivity. So what is measured is the combined effect of the diverse influences at work in a productive function..."[14]

The Keynesian Verdict

Quite a number of other writers whose articles appear in this issue of the journal have supported the concept of labour productivity from a wide variety of standpoints. Theoretically, the Keynesian Verdict is probably the most interesting in the history of economic thought: "...It is much preferable to speak of capital as having a yield over the course of its life in excess of its original cost, than as being *productive*...If capital becomes less scarce, the excess yield will diminish, without its having become less *productive*—at least in the physical sense...I sympathise, therefore, with the pre-classical doctrine that *everything is produced by labour*, aided by what used to be called art and is now called technique, by natural resources which are free or cost a rent according to their scarcity or abundance, and by the results of past labour, embodied in assets, which also command a price according to their scarcity or abundance. It is *preferable to regard labour*, including, of course, the personal services of the entrepreneur and his assistants, *as the sole factor of production*, operating *in a given environment of technique, natural resources, capital equipment and effective demand.* This partly explains why we have been able to take the unit of labour as the sole physical unit which we require in our economic system, apart from units of money and of time..."[15]

In matters of policy, however, we would be concerned not so much with pure theory as to the practical implications of mechanization. If increased mechanization or what is known in this country as rationalization increases productivity, what would be its implications in the context of a large and growing population? The answer to this question is contained in an article, again by Seymour Melman, published in this issue of the Journal on Alternative Methods and Manhours for Production: ....."*Decisions to use one production method in preference to another are necessarily social decisions....*" Probably the conclusion of Professor Jan Tinbergen in the *Choice of Technology in Industrial Planning* would be broadly acceptable: "...Excessive mechanization has at times been introduced in industry in underdeveloped countries in order to avoid 'the trouble of dealing with people', that is, to avoid the occurrence of human errors, and to lessen the effects of labour turnover, burdensome and irksome labour legislation, strikes and so on. *When pushed too far, such practices have had consequences contrary to the basic interests of the national economies concerned. The economic system should be run in the interest of all citizens;* if part of them are excluded from the production process, serious strains may occur in the longer run in the political and economic structure of the country..."

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14. Balkrishna, Dr R., Measurement of Productivity in Indian Industry, Madras University, 1958, p. 2-3.
15. Keynes, Lord JM, General Theory of Employment, Interest and Money, 1960, p. 213-14.

Manhour Versus Machine hour

Even from a purely economic standpoint, the same conclusion has been powerfully supported by the excellent thesis of Sri AK Bose of the Hindustan Aircraft, published in this issue of the Journal: ...."...*Although great scope for mechanisation exists in many facets of industrial work in India, it is still cheaper to employ labour and/or only partly mechanise in order to maintain accuracy of workmanship*...Differences in resource-endowment of various countries are a compelling reason for a significant variation in the employment of productivity techniques...it would cost Indian management about 3½ to 6 times to keep one machine hour idle when compared to one idle manhour...*What is required in India is not so much the immediate necessity for speeding up of pace of the Indian worker in order to catch up with the level of labour productivity abroad, but to try and obtain better utilisation of men and machines through proper planning*...Due to the fact that there is considerable unemployment in India and our industrial manhour rates are possibly the cheapest in the world, *competitive pricing should be logically based on labour intensive processes at a satisfactory level of productivity*..."

Productivity and Profitability

In the measurement of productivity, a more intriguing question arises as to profitability being both a measure of economic efficiency and a management guide to greater economic efficiency, as Joel Dean puts it in a brilliant contribution published in this issue. Profitability as an index of productivity is a widely accepted American idea. Quite a number of new firms organized on modern lines look at productivity from the point of view of *return on investment.* As a supplement to this journal, we have printed the famous *Du Pont Executive Control Charts,* alongside a number of ratios, which that Company works out in considerable detail so as to see whether the results achieved in its various departments correspond to target goals, where things are not as they would like them to be and the points at which remedial measures need to be taken. NPC attaches considerable importance to this line of research and the adoption of this technique as a poweful aid to management. A case study in inter-firm comparison has been printed in this journal which shows the importance of these ratios in management decisions, regarding the stepping up of productivity in the various departments of a concern. Considering the whole perspective of the social economy of this country, we would be inclined to accept once again the conclusion of Dr R Balkrishna : "...Profitability is not directly related to productivity. In cost and profitability, there are so many other factors besides productivity..."

The Conundrum of Cost

It is not a practical proposition here to go into *the fundamental nature of cost.* In productivity discussions, reduction of costs has been emphasised, and rightly so, for we have to make our industry competitive, particularly in view of the difficulties of foreign exchange and the compelling national necessity to increase export earnings as substantially and

as fast as we can possibly do it. But reduction in cost does not mean reduction in wages. Workers being also citizens, the costs of industry have not only to be counted in terms of the wages paid out but really in terms of the total social costs involved. Saving in wages might be more than counteracted by the costs involved in terms of the health and education of the working class, to which our constitution commits us. Such savings might well result into the emergence of a number of concealed costs at other points in the social economy. What really is desirable is not any reduction in the total or the average wage cost per worker but in the wage cost per unit of output. At the first meeting of the productivity study groups set up by the NPC, Sri Manubhai Shah pointed out that we were really looking for savings at a number of points, outside the purely labour costs, such as the wastage in storekeeping or in sales organisation.

Productivity XRay

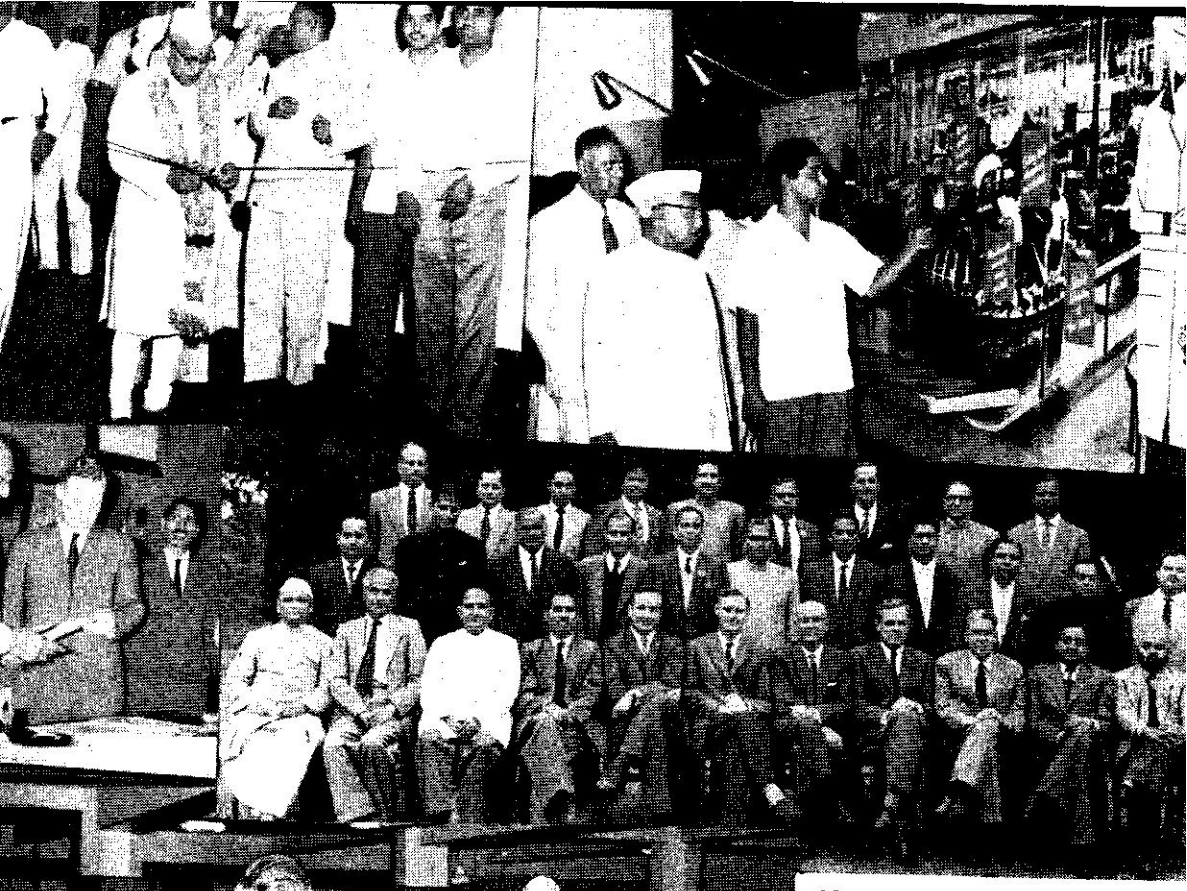
The real fact of the matter is that in the measurement of productivity, the idea of the NPC is to get a productivity xray of the major industries, as the NPC President put it at the last annual meeting of the National Productivity Council held in April 1961, while explaining the proposal of Study Groups to the Council. The purpose behind these Study Groups is to *locate and identify areas and situations of low productivity* to enable remedial action being taken. These areas and situations range from low managerial techniques to unplanned plant layout, crude and wasteful methods of materials handling, medieval techniques of storekeeping, packaging, neglect of marketing etc.

Marketing and Productivity

A reference has already been made to the excellent article of Joel Dean, published in this issue of the journal on the *Measurement of Productivity in Marketing,* which discusses *inter alia* quite a number of important issues relating to measurement of productivity in general. This, of course, is a modern American idea. But it has its basis in classical analysis that the division of labour and its productivity depend upon the size of the market; and an extension of the market, therefore, leads not only to increased profitability but also to higher productivity. The reason why it is necessary to rub it in the context of Indian Economics, is that the neglect of marketing often leads practically to a cancellation of all the advantages in terms of high productivity that a concern might enjoy by way either of skilled labour or superior production management. Marketing here is to be understood in broad terms, meaning not only the strategy of marketing but also an intimate knowledge of manufacturing costs and above all, *a feel of the current of social change* as determining what things would be demanded and at what price. That is why the NPC has been conducting a number of specialised courses in marketing. Most small businesses lose in this country because they do not know the markets in which they buy and the markets in which they sell. *Production processes are not sacrosanct*: they have to be adjusted to market conditions; that in fact is the basis of what we call statistical quality

Centre left: Andhra Chief Minister speaking to APO Team

Centre right: Executive Director N awarding certificates at Ludhiana



Above: Nainital Programme
Top left and right: Governor Madras inaugurating Productivity Exhibition

Consul General awarding certificates, tool
n course Bombay LPC
Productivity Exhibition Madras

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US Consul General inaugurating NPC course on Cost and Budgetary Control

control in the theory of productivity. Really, the whole theory of productivity is that *that concern is the most productive which has the capacity to adjust itself to market conditions.*

Productivity in the Public Sector

It has often been said that the public sector is *not amenable to the criteria of the market place;* that it is difficult, if not impossible, to construct statistical indices of productivity for the public sector enterprises, particularly in the public services. A French contributor to this special issue has shown both by theoretical analysis, as also by practical examples, how public services, even schools and hospitals can be judged by productivity criteria. The real fact of the matter is, and that is the whole philosophy of productivity, that *nobody whether in the private or in the public sector is above judgement* or what the Americans now call *evaluation.* Even the quality of management has to be appraised and measured. *Entrepreneurs,* directors, managers of all ranks, workers, public servants, are all accountable in terms of their production performance, for *whatever each one of us brings to the performance of his task is the result of social investment. Measurement is mandatory.*

END OF THE WORLD SECOND EDITION !

Once the crusty old foreman of a weekly newspaper's composing room was breaking in a new typesetter. He explained the uses of all the various sizes of type, what kind of story took what kind of type, until he came to three trays of very large type, dusty and obviously unused . . . "That first tray of big type is in case the dam above the town breaks," he explained. "The second one is for the end of the world." He turned to go, obviously finished with his explanation . . . "What about the third tray?" the trainee asked . . . The foreman slowly brushed some of the dust off the huge letters, then turned to the trainee. "That's for the end of the world, too," he said. "Second edition".

Productivity or Expensivity ?

ING MANFRED KNAYER

PSYCHOLOGICALLY, THE TERM "PRODUCTIVITY" WAS A RATHER SUCCESSFUL CREATION. For mathematical treatment, it has a great disadvantage: it is not possible to add up the productivities in the different stages and departments which a product has to pass when being manufactured. This may be explained by a simple example: suppose a textile mill employs 125 persons in its spinning department. During an 8 hour shift (= 1,000 man-hours) they produce 4,000 kg of yarn. In the weaving department, 75 operators in one shift (=600 man-hours) convert 4,000 kg of yarn into woven fabric. Then the productivity in the spinning and weaving department is:

P_s = 4,000 kg/1,000 h = 4 kg per man-hour
P_w = 4,000 kg/ 600 h = 6.6 kg per man-hour

There is no sense in adding up the two departmental productivities. The situation improves if we use, instead of productivity = output/input, the reciprocal value, namely input/output, that is the specific effort and expenses required to make a certain product. Because of the lack of another term, this ratio, expenses/yield, may be called "expensivity" (*aufwendigkeit*). For our spinning and weaving departments, we now get the following expensivities, E_s and E_w.

We can now compare the expensivities of the departments of different plants and we find the total expensivity by simply adding the expensivities of the departments a product has to pass through when being manufactured. The same principle is useful when we study the consumption not only of man-hours, but also of materials, fuel, steam and electric power. It does not make sense to add the pounds of yarn per kilowatt-hour of the opening, spinning and weaving departments of a textile mill, but it is good practice to check and add up the kilowatt-hours consumed per pound in opening, spinning and weaving in order to obtain the total energy consumed in processing cotton from bales to the finished fabric. Whenever we accompany a unit being produced on its way and measure what is spent on it (the inputs) during the different processes and in the different departments, we can add up the different inputs (expensivities) of the same kind, and we can also compare this total easily with the total input found by some other method.

In the Factory Performance reports prepared by the US Bureau of Labour Statistics, the man-hours required are usually reported, and not the productivity, which easily permits of adding the

E_s = 1,000 h/4,000 kg = 0.25 man-hour per kilogramme
E_w = 600 h/4,000 kg = 0.15 man-hour per kilogramme

E_{total} = 1,600 h/4,000 kg = 0.40 man-hour per kilogramme

man-hours required in different departments to the total man-hours required for the whole product or unit produced. For instance, one can add up the time required in the cutting, stitching and finishing room to the total time required to make the whole garment or pair of shoes. Funnily enough, many productivity experts and industrial economists have not yet discovered this advantageous principle and still use the term *"productivity"* not only for general purposes but also for detailed analysis.

Parameters of productivity

The model laws are well known to every physical scientist. They say that similar things of different size behave differently even under the same conditions. When two bridges have to carry the same load but over different spans, the bridge with the wider span necessarily will have a higher weight per running foot or meter; a smaller boat needs more horsepower per ton in order to be as a big steamer, and a big tungsten furnace has a better thermic balance than a smaller one.

When simply comparing a 20 HP motorcycle engine of a cylinder content of 500 cm with another engine of only 250 cm, we perhaps might be satisfied when it has half the power, which is 10 HP. But because the model laws are in favour of the smaller engine—they permit higher specific speeds—we are right in expecting a higher specific output per cubic centimeter, increased by a factor of 1: $\frac{3}{0.5} = 1.26$ and only if the smaller engine has an output of 12.6 HP is it "as good" as the larger similar model. (The expensivity, cubic centimeters per horsepower, for the smaller model is reduced by 0.8.)

When comparing single units like bridges, ships or motors, we are able to find such influences, parameters and changing relations by theoretical considerations. It is sometimes possible to find such laws also in productivity measurement, but often we must rely on relations and correlations found empirically.

In the operation of spinning yarn, of course it takes more time to spin one pound of thin yarn than one pound of thick yarn. In fact, the man-hours and spindle hours per pound of yarn spun increase with the yarn count and decrease for the coarser yarns with low yarn numbers. There seems to be an almost linear regression and so we are able to compare the productivity or rather the expensivity of several plants, even when they make yarns of different counts. Such considerations might be just more than only counting and reporting the man-hours and spindle hours of mills making a certain range of yarns. *Technology, industrial engineering and productivity measurement should work closely together in establishing standards for certain products, in finding certain correlations and in working out the influence of such parameters like plant size, quality of raw materials, degree of mechanisation, lot size, etc.* The amount of information and data required for such extended studies is, of course, much larger than just for the comparison of two similar plants making the same product under like conditions, but we are able to include a wider range of plants in the survey.

Suppose we wish to compare a group of shoe factories. They all make one particular model of men's shoes, but, besides this selected model they make a different number of other models and styles. Suppose the following data be given.

Plant No	Time required to make one pair of the selected model	Number of models produced in plants
1	1.00 hours	20
2	2.00 „	60
3	1.25 „	30
4	1.30 „	40

As long as we do not know how much the number of models made in a plant influences the time required per pair, we are not able to state whether plant (2) is better than plant (1). Since we do not know whether there is a linear regression between the variety and the time to be "expended" per certain models, we are not even entitled to say whether plant (3) is better than the other ones, but we are certainly right in stating that plant (4) is better than (3) since it has a variety greater than (3) but requires only a little more time to make a pair of the selected model.

Often we are not able to reach greater productivity, despite the fact that we know what to do, because of the situation or because the higher level of management disagrees with the suggestion. Perhaps in a large country a plant is able to sell all the shoes they can make although they have only a small variety, while in a small country the plant owner thinks it is necessary to offer a great variety, and his plant-superintendent cannot do anything about it (apart from good scheduling). Sometimes we are able to improve one condition but at the same time another condition deteriorates, but at least we have the choice.

When driving a car near its top speed, we increase its productivity in terms of miles per hour, but we decrease its productivity in miles per gallon. We can assign more looms to one weaver and thus decrease the man-hours per pound of fabric, but we must expect more loom stops at the same time and longer delays before the busy weaver can make the loom run again and hence longer average loom stops, less utilisation, more loom hours per pound of weaving and perhaps lower quality.

We know that the Dutch and German farmers "put in" more man-hours in their fields than the American farmers do, but their yields per hectare (or acre) are higher than those in the United States. Which farmers are the more productive ones?

In order to judge them correctly, we should also measure the influence of soil quality, fertiliser application and climatic conditions (which can be expressed in growth units according to Thornthwaite). During the time food was rationed in Germany, farm products were credited to their producers delivering to the collectors by the following equivalents:

1 kg of wheat	=	1 kg of wheat
1 kg of peas	=	1.5 kg of wheat
1 kg of linseed	=	2.0 kg of wheat
1 kg of potatoes	=	0.25 kg of wheat

If these figures were sufficiently exact, we would be able to compare the productivity of a farmer specialising in peas with that of another farmer chiefly raising potatoes.

In foundry work, we are able to decrease the "circulation iron" by making the feeding heads and raisers smaller but at the same time we might increase waste. Instead of cutting out shoe uppers using knife and stencils, we can work much faster with clicker machines and cut out dies, but at the same time our leather consumption per pair goes up (nevertheless a plant using cut out dies might design them very carefully, and by keeping the allowance small, they might require less leather per pair than a plant working with knives and stencils). A trucking company may order an increase of the average speed to obtain a higher ton-mileage, but this might not only result in a higher consumption of fuel and spare parts, but also their accident rate might go up.

Such research requires much work, but will be very valuable and often shows that the actual way of doing things is far away from the optimum conditions, *so productivity measure-*

ment will lead to economical operations and conditions.

Breakdown into elements for inter-industry comparison

The finer we analyse production and the more we go into details the greater are the chances to find operations comparable to one studies in a completely different branch. While it is only of general interest to compare the spinning of cotton with that of worsted and woollen yarn—the machines and methods are too different—it is of considerable interest to compare the productivity of wool cloth with that of cotton fabrics. In studying the making of shirts the cutting operation in a knitwear factory may be compared with that in a plant making popeline shirts. If we go down to the circumference of leather parts expressed in centimeters, round and sharp corners, we are able to compare the time required for cutting any shoe upper with any other, and we can even include the cutting of other leather goods such as wells, wallets, gloves and handbags.

The last step, a breakdown into basic motions, has already been done successfully. The engineers who developed systems like basic time and motion study, Work-Factor and Methods-Time-Measurement, claim that the time for certain moves and reaches with hand or finger, and for similar kinds of positioning, do not differ much whether they are performed by a white or coloured person in Pittsburg, Hamburg or Johannesburg.

Even by not so fine an analysis we are sometimes able to find similar operations in plants of different branches. This does not only apply to floor sweeping. It might well be possible to compare the wrapping and boxing operation in a plant producing paint with the packaging in a plant canning vegetables, or with the shipping department of a meat packing plant.

Comparing synthetic data

For some time the author belonged to a working party of time study men. At every meeting, one of the participants brought with him a few blueprints of a machine part and distributed it to the other members. For the next meeting each of them prepared an estimate of at least one operation of the set-up time and of the time to make one piece (the standard time to make one part). The results were charted in such a way that it was possible to distinguish the set-up time and the time per piece figured out by each of the participants, and it often happened that the time suggested by the man of the plant making the part was not as that of another member and he was able to improve the productivity of a certain operation, for instance by a higher feed or cutting speed or by combing two operations. For plants having a good time study department making similar but not exactly the same products, the comparison of "synthetical" time standards, even when not actually measured by observation but by calculation, is at least a good substitute or ersatz for actual measurement.

Cost accounting, competition and productivity measurement

An old trick of manufacturers to judge the efficiency of their plants is to try to get a bid by a competitor on a product similar to his own, for instance through another firm acquainted with him and handling the enquiry for him. Sometimes such price comparisons were carried out officially but under code numbers by trade associations. If such a price comparison not only contains costs of materials and manufacturing, but also goes down to time standards and overheads of production centres and cost points, it is a very useful method of

judging plant efficiencies. In times of prosperity such studies usually find more cooperation than during depressions.

Finally the ultimate consumer has his own chance to measure the expensivity rather than the productivity at work along the way of a consumer's good from the raw materials through the channels of trade and industry until it becomes his property. He only has to compare the prices of similar goods offered to him by the different systems and trades. Curiously enough, many consumers are not clever enough buyers to use this chance and they often obey the situation instead of looking for the occasion. It would be a good thesis to investigate if any how the ultimate consumer should be trained or educated to such private economy. Nevertheless products of the same quality but with different prices will make the more expensive products disappear from the market, and in fact, competition not only leads to productivity comparison, but even forces manufacturers to increase productivity.

European managers often object to the productivity measurement as done in the USA and consider the methods used there as over-simplified and not applicable under European conditions. The correct reaction is, of course, not to refuse participation but to develop higher refined methods of productivity measurement. A plant building their products "made to measure" should also be able to set up the proper standards and to contribute to the improvement of productivity measurement and to help in developing methods "made to measure".

Productivity and its Measurement

R BALAKRISHNA*

Productivity is an elusive concept that does not lend itself either to clear-cut definition or to easy computation. While the expression is in common use, its exact import is rarely understood. So long as a measurement of it is attempted, the variety of interpretations in current use does no harm. But when some exactitude in the variation of productivity is to be established for bringing theoretical speculation down to the level of practical policy, innumerable difficulties present themselves. It is impossible to circumvent all the difficulties before measuring productivity, because some of them are inherent in the problem. Measurement has to be attempted in spite of them, with full realisation of the limitations of the indices thus provided.

THE ratio of output of the commodity to the input of the factor is the measure of productivity in relation to that particular factor of production. The choice of the factor depends upon the purpose of the inquiry. But generally, measurement of productivity is reckoned in terms of labour. Economists and businessmen have used the term productivity in relation to the output secured for a given amount of labour. Productivity therefore means the physical volume of output attained per worker or per manhour. Thus *physical output in relation to labour input is the norm of measurement.* Therefore, the definition of productivity is the ratio of output to the corresponding input of labour. The purpose of the productive unit is to provide the goods which the community requires at the lowest possible cost measured in terms of expenditure of real resources. Of these, manpower is the most important. So productivity means the volume of output achieved in a given period in relation to the sum of direct and indirect effort expended in its production. This is expressed in terms of either output per manhour or per manyear. While the former is significant for local management, the latter throws light on the wider economic picture.

Though the indices thus derived are based on labour they do not measure merely labour efficiency. It is *actually a measure of industrial efficiency in general, reckoned in terms of one specific factor.* Thus any factor affecting output or labour may have an influence on labour productivity. So what is measured is the combined effect of the diverse influences at work in a productive function.

Labour productivity indices register the influences of several distinct but inter-related forces that determine the output per manhour. The ILO Report on Methods of Labour Productivity Statistics divides such forces into three categories: general factors, organisational and technical factors and human factors. The first group constitutes the broad factors, such as climate, the fiscal system, credit, research etc. It would also include the changing composition of production and the varying

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proportion of low efficiency plants in industrial establishments. The group of organisational and technical factors would include the degree of plant and scale of output, the proportion of mechanical equipment per worker, specialisation and standardisation of output and the length of the working day. The third group refers to the effect of wage incentives and the trade union technique of regulating pace of work. So the effort of labour is not directly measurable unless all these factors are kept constant, which is impossible. What is measured therefore is the combined result of all these forces.

The concept of productivity is of considerable importance, as productivity is an index of economic welfare. It is even more important than production, because the differences in the economic condition of advanced and underdeveloped countries are due more to differences in productivity rather than to their volumes of output. An improvement in productivity can result in extra production without a corresponding increase in either plant or equipment. The increase in output will arise out of a more efficient use of existing plant and equipment, and by the elimination of waste of materials and effort. Hence *productivity measurement is an important tool of economic and social analysis.* It can serve as the basis of business decisions and state policy. Over a period of time, productivity measurements would indicate changes in economic wellbeing and reflect shifts in patterns of living. The short-term movements in productivity would serve as guides in the analysis of current business conditions. Nations are therefore concerned with the variation in their rates of productivity. Improvement thereof is an important preoccupation of modern nations.

In the process of measurement the two important variables are product and effort, neither of which is homogeneous. A large part of the difficulty consists therefore in reducing them to a comparable basis. With regard to product the first requirement in comparisons is to eliminate the differences in their character. As Tippet points out, a narrow range of products must be chosen. They would serve as pilot products representing a substantial part of the output of a sufficient number of factories. The products thus chosen should have some common characteristics, like counts in yarn. Apart from the characteristics of the product, there may also be other factors affecting productivity. There may be differences in the quality of raw material, in the degree of mechanization, in the quality of technical management and in the morale of the operative. But changes in product specifications are of considerable importance. Comparisons of productivity would be extremely unreliable if sufficient cognisance is not taken of the differences in the quality of products. S R Dennison makes a pointed reference to the findings of the Working Party on Wool, which has stated that the difference between the UK and the USA in the physical output per worker in the woollen industry does not reflect differences in efficiency, because American cloth is of inferior quality and more expensive to produce. However, it may not always be possible to get exactly comparable products either between nations or even within a nation. There would thus always be this limitation in productivity measurement.

Similar difficulty arises with regard to labour, which is the other aspect of productivity. Just as product specification is a limitation in productivity measurement, differences in the nature of labour employed are also a serious limitation. For purposes of productivity measurement labour force is treated as a homogeneous entity.

As Evans says, productivity to most people implies the measurement of productive efficiency using the expenditure of human effort as a yardstick. But as Lazare Taper points out, this yardstick or framework of reference is not the expenditure of human effort but the expenditure of time. When all other factors remain the same, variations in physical output|manhour input ratios as between different periods of time reflect changes in the relative average efficiency of the labour force. But of course the composition, distribution, turnover and morale of labour will all affect productive efficiency. Still, as an overall measurement it reflects changes in efficiency. When factors other than labour that influence changes in productivity are taken into consideration, the concept of efficiency becomes a function of many independent and interdependent forces, such as labour, management and equipment. As already observed, if product specifications also change, the meaning of the productivity ratio becomes further complicated. But in spite of all these, as Lazare Taper points out, it is possible to ascribe a significance to a statistical series which would show for the different periods the ratios of manhour input to physical output. It is an indicator of manpower utilization measured in units of time input. This would apply not only to a single plant but also to a group of plants engaged in the production of a single article.

It is also important to bear in mind that there are different kinds of labour engaged in productive activity, such as operating labour, auxiliary labour which is not engaged in direct operation but does subsidiary work like oiling, repairing etc, embodied labour which has been applied in the production of the machine itself, and indirectly required labour for transporting, marketing, etc. Among them embodied labour cannot normally be included. It could be taken in the form of equipment per worker for purpose of comparison. The others have all to be included, though the distinction between direct and indirect labour is not always clear and well defined, particularly as between different countries. A further difficulty is in respect of labour actually at work and labour that is paid for by the employer. Obviously the latter would include labour having holidays with pay. For measuring productivity in the technical sense, the output per worker actually at work or output per productive manhour is relevant. This would of course include rest pauses. On the other hand, in measuring costs of production the output per manhour actually paid for is more appropriate.

A further consideration with regard to labour is its composition. The labour force is heterogeneous because of the differences in sex and age of the workers. The work of labour is not a homogeneous entity because the effort content may differ according to the age and sex of the workers. It is possible to convert all labour to the standard of an adult male worker on the basis of the wage paid or to reckon in terms of equivalent manhours on the basis of work done. But such computations are based only on arbitrary ratios and hence unreliable. So, as Fabricant says, simple aggregation of numbers is the only practicable solution.

Finally, a distinction has also to be drawn between output per manhour and output per man. The two illustrate particular aspects of labour productivity and hence cannot be used indifferently. The manhour concept is useful in determining the output in relation to time or productive capacity. On the other hand, the output per man is appropriate when estimating the manhour requirements or employment possibilities. Since the former concept refers directly to industrial efficiency, it is more relevant in

respect of underdeveloped economies. *So in this work on India it is manhour concept that is taken as the focal point.* It is not however difficult to calculate the output per man with the data collected for measuring the manhour requirement for varying volumes of output.

In productivity measurements physical output should always be preferred to value data, as the latter do not correctly measure changes in quantity owing to variations in the value of money. But if the physical output is not in comparable units, measurement should necessarily be on value basis. When output is composed of a multiplicity of products, monetary value is the only crude measure available. But since it does not take into account the changes in the value of money, it cannot be used in studying trends in effectiveness. So it is necessary to take a corrected monetary value of output when the purpose is to study the rates of change in output of industries with complex and varying forms of output. Here the effect of price changes would be eliminated. The method that is generally followed is to reduce the total financial value of the output to a base year value by using a price index for the group of products concerned. Then, by a system of weightage, the contribution of different products may be adjusted to that of the base year. Finally, the volume of output thus derived for the current period may be compared with the manpower employed in order to measure productivity. When compared with a base year and expressed in terms of index numbers, the trends of productivity may be judged. But this is neither reliable nor adequate, as the price indices used for deflating a value series are not always suitable for measurement. In spite of it, when standardized units are not available for measuring physical output, value data have to be substituted.

The relation of costs and profitability in this context is also of some importance. A question is generally asked whether high production would result in low cost. In the first place, cost figures are not always available. Even where such data are available, there does not seem to be any such relationship between production and costs. At any rate, *profitability is not directly related to productivity.* In costs and profitability there are so many other factors besides productivity.

Techniques of measurement

Prof L Rostos suggests three alternative methods of calculation with particular reference to international comparisons. The first of them, known as *the global method,* is based on the comparison of the total volume of output and total employment in a given industry of the different countries. It may be adapted for purposes of a single country by taking the volume of output and employment for all industries at two different periods. The second method is known as *the sample method* which is based on the comparison of the performance of a small number of selected mills producing identical products under broadly identical conditions. The third is the *net output value method,* which is based on a comparison of the value of net output per head in the two countries, converted into the same monetary unit.

For combining non-commensurate entities into a single index Lazare Taper suggests a technique which consists in the construction of a combined index for a group of products by weighting manpower utilization figures for the individual commodities by the units of physical output for some pre-selected weight base year. This is called the *Index of Manpower Utilization on a Fixed Weight Base.*

The ILO Report on Methods of La-

bour Productivity Statistics suggests four possible approaches to the measurement of labour productivity with unit labour requirements as the basis instead of physical output per man-hour. The first of them compares the total volume of labour required to produce the same complex of goods in two different periods. The complex of goods may be either the production composite of the base period or of the current period. The former will measure the ratio of the labour spent in the current period to produce the base period complex to the total labour actually expended in the base period. Conversely, the latter will indicate the ratio of labour actually spent to produce the current complex of goods to the labour that would have been spent in the base period to produce the same complex.

The second approach requires that the variations of the unit labour requirements for a certain production composite should be an average of individual indices of unit labour requirements. The third approach is to compare the average unit labour requirements needed in the current period for its own complex of goods with a similar average for the base period. The fourth approach consists in relating the variations of the total labour expended in each period to the variations in the total output of each period.

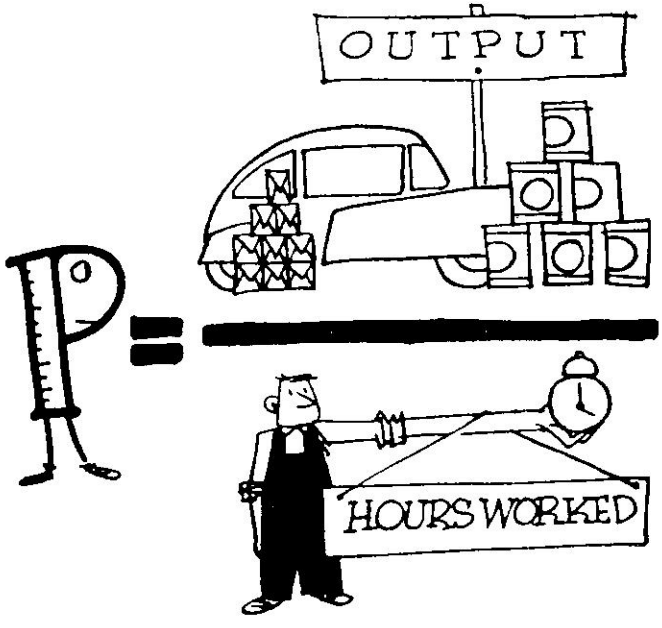
Purpose and policy

The obvious purpose of such measurements is to assess the trends in productivity. Such measurements of production, as already pointed out, are important tools for the analysis of economic and social problems. Productivity measurements should lead the authorities to the implementation of devices, suitable for each occasion, for an augmentation of the physical output. Standardization of products and an allround initiation of economy methods successfully tried in particular plants, would be some of the lines on which economic policy could be framed for the general benefit of the nation. Interplant variations in productivity may be great and it should be the responsibility of state authorities to coordinate the methods followed in order to raise the general level of efficiency. When the average productivity of the industry is calculated, the less efficient firms would know the scope for improvement. When existing technical and economic conditions are related to productivity variations, it is easy to discover the means for improving productivity. So even though productivity measurements can never be absolutely fair, they can serve as a stimulus to producers to investigate their own productivity and find means for improvement, which would always be available. As Tippet says, even crude indices have some value when used as pointers.

Productivity ?

PETER O STEINER
AND
WILLIAM GOLDNER*

Though the terms *productivity, workers' productivity,* and *productivity of labour* are in everyday use, their meaning is not always clear. It is necessary to define what productivity is and *what it is not.* The agencies which measure productivity must have a clear idea what they mean by productivity.



Production vs. Productivity: Everybody knows what we mean by physical production: the number of units of output produced in a given period by a worker, plant, firm or the nation's economy. *Productivity* differs from *production* because it concerns not how much is produced but rather how efficiently production is carried on. Efficiency is measured by counting how much output is achieved for each unit of input.

What do we mean by input? typical product is a combination of ra

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materials, machinery, workers' time, power and many other factors. Each of these is called an input. Input items are combined in the manufacturing process into products or output. Should the unit of input be one worker, or one hour of labour time, or one machine, or a ton of raw materials, or a kilowatt hour of electricity? Any of these could be a unit of input even though each is different. It is necessary to *choose some yardstick of input which is commonly understood and universally present.* For this reason the input factor which is most frequently taken as the yardstick is a manhour of working time. The reasons for selecting labour time as the unit of input are: first, it is present in all production; second, because *we are a society of men, not machines; we are especially interested in how man's efforts are used;* third, better statistical records exist for employment and hours worked than for most other factors that serve as inputs.

Calculating Productivity: Productivity is usually measured by dividing output in physical units by manhours worked.

$$\text{Productivity} = \frac{\text{Units of output}}{\text{Manhours worked}}$$

Productivity could also be measured as, say, output per kilowatthour of electric power, or output per ton of some particular raw material. These would be different measures of productivity and they are *not generally used.*

What causes Productivity to change: The fact that the conventional yardstick of input is a manhour of labour time *does not mean that measures of productivity are related solely to the efforts of labour.* This may be illustrated by the following example. In a certain plant in 1939, 1,000,000 units of output were produced 25,000 manhours of labour. In the me plant in 1961, output was 1,500,000 units through the use of 30,000 manhours of labour. Calculating productivity from these figures, we get

Productivity in 1939 =

$$\frac{1{,}000{,}000 \text{ units}}{25{,}000 \text{ man-hours}} = 40 \text{ Units per manhour}$$

Productivity in 1961

$$\frac{1{,}500{,}000 \text{ units}}{30{,}000 \text{ man-hours}} = 50 \text{ units per manhour}$$

This increase in productivity between 1939 and 1961 might have come about in any of the following ways:

(1) The workers may have become more highly skilled, or they may have *worked harder* (2) The company may have increased the number of machines per worker, or it may have found better machines which enabled workers of the same skill to increase their hourly production; The quality of raw materials may have improved so that less output had to be rejected. Thus, less time and effort was lost in handling materials. Similarly, the proportions of various raw materials involved may have changed and permitted use of less labour and more machinery (4) The organization of production may have been changed to make it more efficient. For example, an assembly line may have been introduced, with consequent saving of time and effort. Or, as a result of better purchasing procedures or methods or materials handling, adequate supplies of raw materials may have been on hand, *eliminating bottlenecks in the flow of production* (5) The increase in output may have resulted from operating at capacity. Neither men nor machines stood idle for lack of production orders.

Actually the increase in productivity probably occurred not as a result of one of the factors alone, but as a result of several of them. For instance, between 1939 and 1961, *the developments resulting from the wartime economy may have laid the groundwork for higher productivity in the future.* The building of a new plant, the redesigning of the production process, the spread of skills to workers who previously had none: all of these improvements have left a legacy in that particular plant.

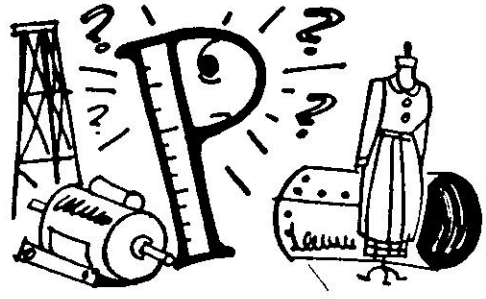
How is productivity Measured? Productivity measures may be computed at virtually all levels of productive activity. The most convenient place is at the job level where output can usually be easily

defined and records of output and manhours are frequently available. Measurement at the job level is of substantial interest to the job foreman or plant manager. Because it focuses on a specific job, however, it is particularly subject to the effects of unusual factors, such as temporary bottlenecks, variation in individual work performance and climatic changes. Notwithstanding, *work performance records are a kind of productivity measurement* carried on in countless business enterprises.

At the plant level, productivity measurement generally proceeds by calculating the ratio of plant output to the total number of manhours worked. At this level, output measurement becomes more complex. Many plants produce a variety of products and combining production figures on different items raises problems. Another difficulty arises because total manhours worked includes not only direct labour but also supervisory, clerical, maintenance and administrative labour. Further, it is *not always easy to segregate the portion of total manhours that is concerned with current production from that chargeable to past or future production.*

The US Bureau of Labour Statistics compiles indices of productivity at the industry level. Here, the problems of measurement are intensified and several complex techniques have been developed to obtain accurate and consistent data. Fortunately, some of the irregular factors present at the job and plant level may cancel each other out. As the coverage of the measures increases, they become of interest to a wide group of people and have greater applicability to general problems.

Despite this interest, productivity indices are available for only a limited number of industries. The primary limitation is the inadequacy of physical production data on a measureable and comparable basis. Industries producing a relatively homogeneous product are heavily represented. Sugar refining, flour, fertilizers, glass, meat packing and petroleum refining have a large proportion of production in simple, continuously flowing, identical units of output. Even where the end product is differentiated but measureable in distinct units, productivity indices can be calculated. For example, basic steel, autos, boots and shoes, and canning and preserving are industries of this type.

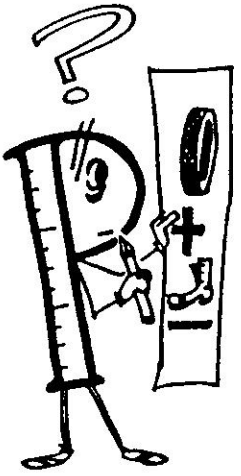


Industries like men's and women's clothing, fabricated metal products and electrical machinery are among those for which industry-wide measures are unavailable. The variety of products, many made to special order, and the different kinds of units which are produced make it very difficult to obtain

statistics of production that directly measure the output of these industries.

Productivity at even broader levels is of greater interest to most economic analysts. They often seek measures of productivity for groups of industries such as, for example, manufacturing, transportation and trade which are important sectors of the economy. These measurements are usually obtained by averaging data for individual industries. Sometimes they are computed directly for the broad sectors where general production data are available. Occasionally, a still broader outlook is required and productivity measured at the national level. We then have to use data on Gross National Product, which is the nation's output of goods and services in terms of its market value. In order to reduce Gross National Product to physical output quantities, these data have to be adjusted by complex price series. The several levels at which productivity is measured make comparisons of the data difficult. Output per manhour at the job level may be used to compare one worker with another or a group of workers with other groups. But *measures obtained at one level cannot meaningfully be compared with those of other levels.*

Measuring Physical Output: The chief problem at all levels is measuring physical output. There is the least difficulty in the case of a plant that is making a single product. Output can be determined by simply adding up each day's production of the finished item. Even here there may be a problem if the quality of the product is changing. If a plant makes many different kinds of products, or if we are concerned with the productivity of an industry or say, the manufacturing sector, it is impossible to add up output of different goods. We cannot, for example, add automobiles and cotton cloth and men's shoes. Neither can we use rupee value without introducing price changes into the measure of productivity. The solution of this problem lies in the construction of index numbers. The process of computing index number is complex. A simple example will indicate the kind of computation. The following hypothetical data represent three items of production in 1946 and 1961:



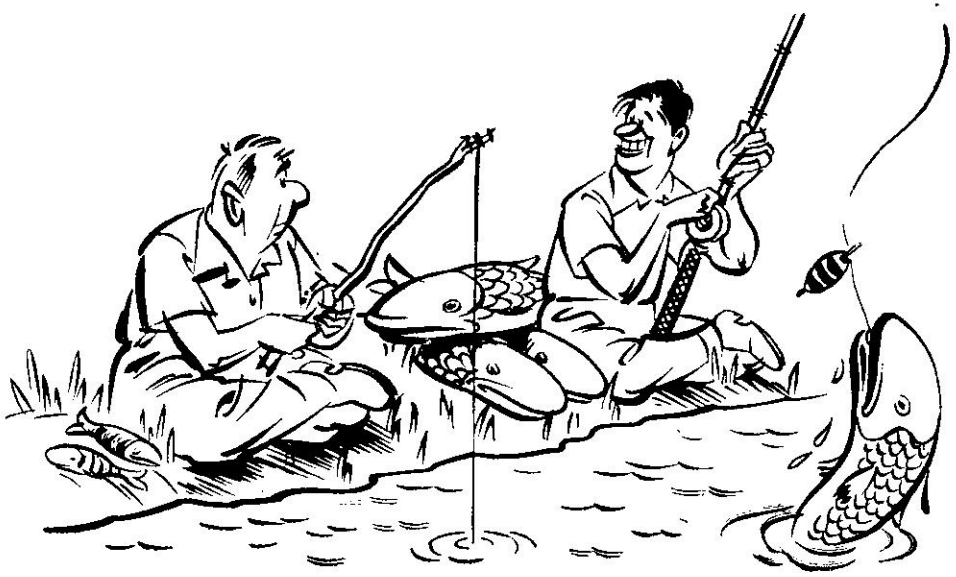
Commodity	1946	1961	per cent Change
Cotton cloth	20,000,000 yds	30,000,000 yds	+50
Cement	60,000 tons	75,000 tons	+25
Apple cider	100,000 barrels	115,000 barrels	+15

In this example output has increased for each of the commodities. It is greater by 10,000,000 yards of cotton cloth, by 15,000 tons of cement and by 15,000 barrels of apple cider. In terms of percentage changes, output went up between 15 and 50 per cent. Since this range is large we may prefer to describe the change on the average. If the three commodities are considered equally important, the average production increased $\frac{50+25+15}{3} = 30$ per cent. However, it is unlikely that the commodities are of equal value, and hence some weighting of the commodities is

necessary. If for example apple cider is of lesser importance we would not count the percentage change in its production as heavily as that of the other items. Index numbers are computed on the same principle as the above example. Changes in the production of specific commodities are expressed in percentage form and these are combined into an overall measure of change by weighting each commodity by its relative importance.

Another index of physical production that is sometimes used, particularly at the sector or economy-wide level, is based on value figures adjusted for price changes. For example, sales figures for a given industry combine the effect of changes in output and changes in prices. If such figures are adjusted for changes in the price level, we will have an approximation to the change in output. This process, called statistical deflation, is often used and is evidenced by such phrases, as in constant rupees, in *purchasing power rupees or in terms of 1939 prices.* The statistical difficulties in finding the price index that adjusts the values properly are very great, and the results should only be taken as approximations. This is the method used in computing productivity measures for the whole economy where Gross National Product in constant rupees per manhour is taken as the measure of productivity.

Every measure of productivity is some kind of an average. The farther away from the job level the greater is the averaging of many products and plants at the industry level; of many industries in addition at the sector level. The measure of productivity in manufacturing, for example, is an average of changes in a great variety of products, in 458 industries, and in about 350,000 establishments. *Productivity measures are not precise statements of specific facts; they summarize the general drift of the changes in productivity of the many plants and products involved.*



The Concept of Productivity

Some think of productivity as a measure of performance of the economy as a whole. Others think of productivity in terms of individual industries or plants. Some businessmen, in their public orations, speak *as though the whole matter of productivity had to do with the degree of application of workers to their jobs.* At other times, the concept of productivity is used as though it were a measure of the degree of efficiency achieved in production. The dictionary merely tells us that this word stands for the *quality or state of being productive.* One thing common to all these concepts of productivity is the desire to portray someone's ability to produce or the rate at which production is carried on.

PRODUCTIVITY MEASURES OF ALL KINDS have been made; production has been compared to the surface covered or available, to the cost of buildings, to energy provided or consumed, to invested capital, to the total cost of planning and even to the average temperature of the premises. Production can also be compared to the quantity of raw materials used. Other things being equal, the results will yield interesting indications of the degree of waste, the degree of technical efficiency of certain machines or methods etc.

Historically, government and private research workers have usually defined and measured productivity as the ratio between production (or output) and the expenditure of some resource used in production (or input). *The greatest interest has always centred in the relationship between production and labour, the universal resource,* and term "productivity" is frequently used without qualification to refer to this ration.

Measurement of labour productivity enables answers to be made to such questions as the following, taken from the report of the United States Works Progress Administration:

(1) What relative volumes of labour time are required to produce a given composite of products at different times? (2) What relative volumes of production of a given amount of labour time? Answers to these questions are of use in estimating (1) employment requirements for different levels of production and (2) future production under various conditions of availability and utilisation of labour.

The first approaches to the subject of measuring labour productivity generally referred to the ratio of production to labour. But in everyday practice, *this ratio, while full of interest has often proved to be more difficult to use than its reciprocal,* termed "unit labour requirements" or "man-hours expended

* Seventh International Conference of Labour Statisticians, ILO, Geneva

per unit of production." "Unit labour requirements", expressed in terms of hours worked in order to produce a defined good, can be directly added or subtracted. The advantage of this characteristic of unit labour requirements is particularly important when comparing the productivity of labour to two undertakings, only one of which is integrated: manhours expended per unit of output can be shown for each stage of production, and comparisons can therefore be made between corresponding stages, with figures stated in terms of output per unit of labour this is difficult or impossible. Thus, if comparisons are required between two cotton textile plants, in one of which the cotton is spun and then woven, whilst in the other only the weaving stage is performed, if unit labour requirements are computed it will be possible for the first plant to show separately, in the total unit labour requirements, those needed to spin the cotton and those needed to weave it, and therefore comparisons will be possible with the data collected for the second plant.

Moreover, no reference to the efficiency of the workers is implied in the number of manhours expended per unit, but rather the amount of labour required having regard to the possibilities or drawbacks of the techniques used; in other words, the influence of factors other than that of labour alone is obvious.

Various aspects of labour productivity

This article is confined to the discussion of methods of measuring productivity, and therefore does not deal with economic or social aspects of the question. It might, nevertheless, be useful to touch upon some of the aspects of labour productivity that might bear a relation to its measurement. *The economic usefulness of the output does not affect the level of productivity.* Whether the placing of publicity posters is economically "useful" or not has no bearing on the fact that the bill poster can post so many posters (of a given size) per hour of work. The economic usefulness of the posting may be important, however, in considering at the national level whether spending time and money on advertising constitutes the best investment of national resources.

Should a distinction be made between 'manual' and 'non-manual' productivity of labour? A simple example of the first is the productivity of a piece worker, while the second might be exemplified by the productivity of a research chemist. There seems to be no difference in concept between these two types, but only a *difference in the possibilities of measurement. But there is certainly such a thing as the productivity of labour of the usherette in a theatre, of a waitress in a restaurant, of an office clerk, of a telephone operator, of a translator, a librarian,* etc., even though the productivity of such persons is difficult or impossible to measure because of the difficulty of measuring their production. The case of the single independent worker seems simple in most instances, his output and the labour he contributes can easily be defined. The cutter in a tailor's shop will prepare a certain number of pieces per hour for the making of overcoats; the miner cuts a certain weight of coal per day etc. Special problems arise for "non-manual" workers, as cited above. It is difficult to define the production of an office clerk who is not assigned an entirely routine job; to define the production of the supervisor of a gang of workers is still more difficult.

It is important to note that even for the simple case of a single worker, the productivity of labour is not identical with efficiency; it is not solely a measure of the worker's effort. The faster

a sweeper works and the less time he loses, the faster the floor will be cleaned; but if he sweeps the same floor with a better broom, he will be able (for the same effort expended) to finish his job in a shorter time. If he is given a vacuum cleaner he may not go any faster, but the job accomplished is not entirely comparable to the previous one; the production is somewhat different in quality: the floor is cleaner. *A worker is thus not the complete master of his productivity; the tools or machines used, the technique followed, the quality of raw materials consumed, etc., have in most cases more influence on his productivity than the effort he expends.* This fact had already been stressed as early as 1898:

> In what is termed the "hand" method of production, machines have been used. It is true that the machines thus used are generally of the most simple kind, such as the saw, the hammer, the chisel, the pick, the shovel and the knitting needle; yet these are no less machines than the larger or more complicated ones used in what is termed the machine method.

A distinction might also be made between machine-paced and man-paced work. There is a wide difference in the output of base paper, which is dependent on the speed of a paper machine, and the number of bricks laid in a day, which is the result of conscious control by the individual operator. Wherever there is a chain assembly or an automatic machine, the standard capacity of work is known. In the case of the line assembly, the employee must keep up to this capacity. Thus, it should be clear that *the productivity of a single worker is that of a unit, "man plus machine,"* that is, the productivity of the worker with a given set of tools or a certain machine, and therefore does not depend solely on the worker's effort.

The next level is that of the gang of workers. Here the productivity of labour is a consequence of a number of combined factors. *The ability of the supervisor may have as much influence on output as the individual efficiency of each worker.* In most cases, however, the production remains easily definable, since the gang is normally assigned a complete job; it might even sometimes be easier to define the production of the gang than that of each of its workers.

The measurement of labour productivity of an entire workshop will encounter many of the difficulties involved in measures for larger units. Management influence is increasing; 'auxiliary labour' (clerical workers, errand boys, etc) contributes to production. Production itself may already be heterogeneous, and this will raise the problem of addition.

When a large undertaking is considered, heterogeneity of production becomes a major difficulty; an automobile factory may also produce automobile parts, wheelbarrows, toys etc in addition to automobiles. *Management intervention, specialisation and division of work, the establishment of standards, recruitment policies, the building up of stocks, etc, introduce many problems which are ignored at the job level.* Hence, the productivity of labour of an undertaking becomes a complex concept.

At the next level, the industry, the questions to be solved become extremely difficult. The obtaining of statistical data will be impeded by the lack of comparability of accounting methods in different undertakings, and the differences in production, as well as by the administrative problems of securing data; the varying composition of the production may have a considerable influence on the results; thus the statistical problems may appear insuperable, and the solutions adopted will differ according to the purpose of the enquiry.

The preceding remarks apply mainly to manufacturing and mining. But the manufacturing industries in any country at most represent less than half of the economy as a whole. Even in the most industrialised countries, mining, manufacturing and the construction industries together do not attain 50 per cent of the total: for example, in Belgium these industries occupy 48 per cent of the total labour force, in Czechoslovakia 39 per cent, and the United States 33 per cent. In other countries the same three groups represent altogether about one fourth of the economy, while in underdeveloped countries they often hardly amount to one tenth. However, the bulk of the studies on labour productivity relate to manufacturing, and it would appear that the importance of this part of the economy has often been overemphasised, at the expense of agriculture, transport, trade and services. The main reason lies in the fact that problems of measurement are much more difficult in these other industries.

In transport, for example, 'output' is never very obvious: *what is the output of a bus driver, or of a bus company?* It it the number of persons transported or the total 'man-miles' accomplished? Disregarding the problem of collection of data, neither of these measures of production (or any other conceivable one) is very satisfactory. For example, the total money collected from the persons transported can be compared to employment or man-hours; but it is obvious that such measures are quite remote from the basic notion of productivity of labour. Further, here also personal efficiency has little effect on the output; the number and quality of guards and drivers on a train is independent of the number of passengers, though, of course, they have an important bearing upon accidents and the successful performance of transport activity.

Nevertheless, measures in this field are of great importance: the competition between rail and road, and the comparative advantages of each should be, for instance, tested by the number of manhours required for the accomplishment of a certain task, e.g. the transport of a ton or a unit of money's worth of merchandise.

The measurement of productivity of labour in trade and services is extremely difficult, because these functions are of a service nature for which there is normally no unit of physical measurement. It would be of the utmost importance to develop such measures, but owing to the problems involved, very little has been achieved in this direction.

It would also seem important to *know something about government productivity in order to measure average productivity for the economy as a whole*, to understand employment trends in the service industries, and to estimate rationally the budget requirements of the various Government activities and services. Here, however, adequate statistical data are lacking. Such measurements are possible where the output productivity by government is similar to that produced in some private industries in which physical productivity can be measured; where units of output cannot be counted as is true in much public employment no satisfactory method has yet been put forward. It is relatively easy to determine the production of a piece worker at his machine or of an automobile plant; it is not feasible to determine the 'production' of a civil servant drafting laws, or the production of a government department as a whole; it is still more difficult to judge of the production value of negative conclusions reached by a research chemist, or of the presumably tremendous productivity *of the discoverer of atomic energy.*

Disregarding all such extreme examples, it may be asserted that trade and service industries, as well as Government activities (national defence, public administration, the judicial system, etc.) clearly contribute to the economy, though the contribution cannot be measured in terms which are comparable with those used in measuring the contribution of sectors of the economy which produce physical commodities.

Finally, certain methods of measurement have been used in an attempt to evaluate the total economic activity within the country, usually in monetary terms, and their use in conjunction with employment and manhour statistics provides valuable information. For example, in recent years gross national product statistics have been divided by measures of manhour input to show the trend of *gross national product per manhour*. Although this relationshop is of importance, it is essentially a monetary measure, and *as an indicator of productivity must be interpreted with care.*

I LIKE A MAN WHO CAN GIVE A STRAIGHT ANSWER

It was a hot August afternoon and we all sat around there in a big circle. Heinzer did the talking. He just went on and on about the company, and what a good place the company is to work at, and how democratic it is here, and how everybody can talk to anybody they please about any gripe...He told us about how the piecework system was set up so that nobody could hang on anybody else's shirttail. He said it was every man for himself ... "Now say that you want to buy a suit and you have a friend who is in the clothing business, you might go in and say, 'Look here, Joe, I'm looking for a suit and I want to pay about $25 for it. What have you got?' Joe shows you what he has in stock and you're pretty well satisfied with one and you say, 'I'll come on Monday with the money, Joe.' And you go out, but while you're walking down the street you see this other suit in the window. Just the same suit Joe offered you for $30, but this outfit only wants $25. All right, young man, which suit do you buy?... Heinzer looked right at me, and I knew what he was getting at. So I thought for a minute and I said, "I'll buy the $30 suit and lose the extra $5 if I can help a friend out"... Heinzer didn't know what to say. He took off his hat and wiped his forehead with his handkerchief. Then he said, "But that isn't good business, young man"... I said, "When it comes to buying a suit from a friend or from some other fellow, I'll buy from a friend, and I don't care about business" (We knew we were both talking about piecework)... Heinzer thought for a long time and then he said, "But that's not the way the world is run Now. what would you do if you were walking down the street with your wife and met another friend, and this fellow was wearing the identical suit with the one you had on and your wife was with you and his wife was with him, and your wife said to this fellow, 'Why, that's just like Joe's suit, how much did you pay for it?' And the fellow said 'I paid $25 for it at such and such a store ... and bought my wife a new hat with the five dollars I saved by not trading at our mutual friend's store'... I said to Heinzer, "Whoa, just a minute! My wife wouldn't say such a thing. My wife isn't selfish. She would want me to do the right thing by my friend." That ended Heinzer's talk... He just said, "I guess that'll be all for today, boys." As we walked out, he said to me, "That's all right, son. I like a man who can give a straight answer." Like hell he does.

Significance of Productivity Analysis

MM MEHTA*

The methods of productivity measurement and analysis have made an important contribution towards the objective evaluation of the temporal, spatial and cross-sectional changes that are profoundly influencing the organisation and structure of individual industries. This new but striking development reflects the growing importance and recognition that economists are giving to the exploratory, fact-finding and empirical studies designed to test the validity of some of the theoretical assumptions, economic hypotheses and postulates which for decades have remained the cornerstone of all economic generalization. The imperfections and inadequacy of many of the economic assumptions and hypotheses to describe the actual situation, have necessitated the development of some objective measures of economic activities. These objective measures undoubtedly furnish powerful tools of economic analysis, for with the aid of these objective measures it is possible to evaluate, with some degree of accuracy and precision, the nature and magnitude of economic change. There is growing recognition of the fact that as tools of economic analysis, the objective measures are more precise and intelligible, for they give quantitative expression to the otherwise imperceptible and indiscernible economic phenomenon. It is hoped that the development of the objective measures of economic activities would tend to bridge the seemingly unbridgeable gulf between the theoreticians who live in their own circumscribed *apple-pie world*, and the businessmen, investors or statesmen who constantly *strive to probe the reality*.

IN RECENT YEARS, PRODUCTIVITY INDICES are increasingly used as objective and scientific indicators of the changes in the economic and industrial organization of the country. Indeed, productivity indices have been used for a variety of objectives at different levels of economic activity. At the national level, productivity indices have been used as objective and scientific measures for forecasting the possible trends in the major sectors of a country's economy and in the appraisal of economic conditions and prospects. They have often been characterized as a *barometer* or *bench-mark* of a country's economic and industrial advancement, and have been extensively used both by economic historians and analytical statisticians for the inductive and historical study of such abstractions like economic development, growth and progress. Productivity indices have been used for estimating the future trends of employment, output and standard of living and in the selection of productivity techniques most appropriate in the prevailing economic and industrial conditions of the country. There is hardly any doubt that productivity indices are serving as valuable guides in the formulation of government, business and labour union policies relating especially to wages, prices, employment and hours of work. On the national level, productivity indices are also used for estimating the measure of protection to be granted to each industry or product against in-

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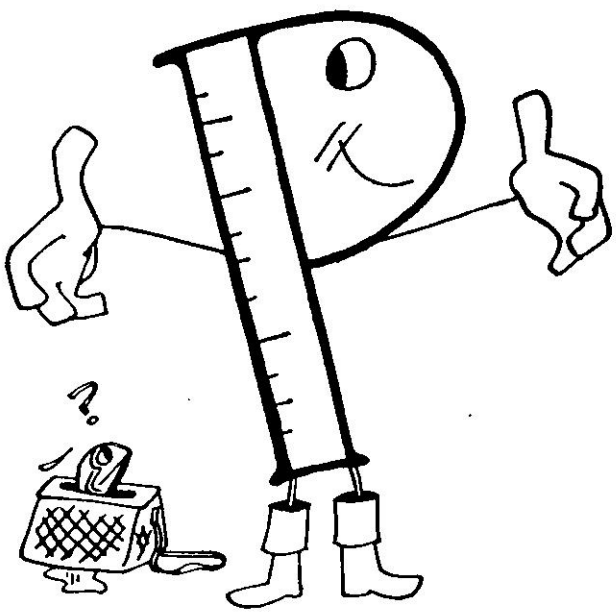
ternal or external competition; in the formulation of appropriate taxation and fiscal policies and in the extension of social insurance and labour welfare schemes. As scientific and objective measures, productivity indices are entering more and more into national policy and decision-making.

But more important and significant has been the contribution of productivity indices towards the inductive and analytical study of industrial conditions and prospects. They are increasingly used for analysing and examining the principal trends in the organization and structure of individual industries; for estimating the nature and extent of long period changes in the productivity efficiency of the industry, and for studying the degree of inter-regional and inter-unit differences in the productivity of different industries and of different enterprises. There is considerable evidence that productivity indices are now extensively used as objective measures for studying the distribution of the fruits of production among all parties as interest. In no small measure, are productivity indices helpful in evaluating the influence of technological changes on the volume of employment, in analysing and forecasting the future trends in productivity, employment and demand for the product of the industry, and in the formulation of national schemes of allocation and utilization of natural and human resources which would maximize national welfare. Similar use has been made of productivity indices in studying the influence of taxation and fiscal policies on the growth and expansion of individual industries and in the inter-comparison of productive efficiency of industrial units, located in different countries, so as to arrive at a fair measure of protection to be granted to individual industries. Many interesting and thought-stimulating studies have also been undertaken by students of industrial economics to discover the degree of relationship between *productivity and size, productivity and technology,* and *productivity and prices*: whether and how far are these different variables inter-related.

At the department and job level, productivity indices are used for evaluating the effectiveness of the various schemes of rationalization and scientific management. They tend to indicate whether the introduction of a new labour-saving device or new wage system has led to a significant increase or decrease in the productivity of labour or other input factor. They are exercising greater and greater influence over management's policy and decision-making. A prominent and outstanding example is the promise of higher wages based on productivity improvement factors. Productivity indices have also been used for motion and time study; for quality control, for operation analysis, and for production planning and inventory control. They have also been used in salary and wage administration and in personnel management. With the introduction and extension of *work measurement* programmes, greater attention is being paid to the systematic recording of productivity performances both on the departmental and job level, and considerable time is spent in the analytical study of productivity changes. Not infrequently comparisons are made between *standard* and *actual* performances, and even wage-adjustments are sometimes made on the basis of productivity performance. There is hardly any doubt that factory or departmental managers often use the productivity indices for the objective evaluation of the success of their various *incentive* schemes.

The foregoing survey clearly reveals that productivity indices are now being used for a variety of objectives at different levels of economic activity. Their utility is not merely confined to analytical statisticians or industrial engineers who are mainly interested either in as-

certaining productivity trends for whole industries or nations, or in measuring performances at job levels; they are equally useful as tools of economic analysis and appraisal to statesmen, businessmen and labour union leaders, who wish to pursue a more realistic policy based on observed facts and the significance of those observed facts to prevailing economic and political conditions. In recent years considerable emphasis has been laid on increasing productivity as a means for promotion of general welfare and for achieving higher standard of living. There is a growing belief that the relatively higher standard of living of the American citizens has been the direct consequence of higher productivity in their national economy. Dr. Laszlo Rostas in his brilliant and scholarly work on 'Comparative Productivity in British and American Industry' has attempted to show that for manufacturing industries as a whole, *output per person employed was roughly twice as high in the United States as in Britain.* There seems little doubt that the high and steady rate of growth in production per manhour in the USA has primarily resulted from the continued *acquisition of technical knowledge and its steady application to jobs.*



Aspects of Productivity Measurement

IRVING H SIEGEL*

The interest in labour-saving technology in the United States is deeply rooted, extending back even to colonial times. The tradition of productivity measurement is hardly as venerable or as continuous, but it may be traced at least seven decades to the first years of the US Bureau of Labour Statistics. Despite this long history, a seasoned and critical observer is still impressed with *the crudities of the theory* and practice of productivity measurement and with the consequent need for *elevating the standard of makers and users of productivity indexes.*

UPGRADING THE SOPHISTICATION OF THE makers and users of productivity indexes is the key to the improvement of data by government and by business firms, to the advance of measurement art, and to the rise in the quality of applications. But the task of raising standards is not simple, for one thing, the population of statistical workers, economists, business analysts, etc, having occasion to deal with productivity is a shifting one, and it is also characterised by a wide diversity of primary interests. Over the years, only a small band of devoted productivity students remains. Users tend at first to ignore the methodological details of productivity indexes, like the fine print describing the contents of favourite patent medicines. *A certain purism is desirable* in appraising the appropriateness of techniques employed and applications made.

We restrict the sense of *productivity* here to the class of conceivable measures depicting output per unit of associated input in a sequence of compared periods. We say *associated* rather than *corresponding* because the input and output figures are most often dissimilar in scope. For example, output is typically measured gross with respect to input, thus reflecting the contribution of all rather than of the last few stages of productive activity.

Although productivity may be conceived with reference to any or all input factors, practical choice is limited to the significantly measurable ones. Measurability is hampered by the extreme heterogeneity of a definable input class, either within a given period or over time. (Heterogeneity of output will be considered later). Thus, the essence of entrepreneurship cannot be captured by *so spiritless a measure as manhours.* Nor can the 'volume' of capital services be satisfactorily reflected by routine deflation, by the division of total payments for such services by (say) the 'price' of a particular unchanging variety.

The input elements contributing to a given product complex cannot always be elucidated completely. Certain private costs of production are transferred to society, and some business services are provided by government at less than full cost or 'free'. Some factor inputs are also obtained free from nature or have not been reckoned correctly in the longterm normal price of 'land': air,

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sunshine and rain. Some intermediate social product is privately appropriable, so that *a firm may reap where it did not sow*: scientific knowledge, public patents, technological applications developed at government expense (e.g. on war contracts) etc.

Labour productivity measures are computed for a variety of reasons. One is the practical measurability of labour. That is, crude summations of workers or manhours of diverse skills are commonly accepted, even as population totals including persons of both sexes and in different age groups. A second reason is the actual or assumed relevance of the labour productivity concept to various problems—like the analysis of trends in wages and unit labour costs, the comparison of wage and price flexibility, and the projection of employment or output. A third reason stems from the *dual role of man as the end of production as well as a means of production*, as the seeker of maximum material welfare with minimum work (and, *a fortiori*, maximum voluntary leisure). *This humanistic view, treating technological advance as incidental to the struggle of man against nature, seems especially appropriate for the very long run.*

All intermediate production : the creation of institutions, knowledge, non-human energy, processed materials, capital instruments etc, may be regarded as strategic, as presumably leading to a larger flow of ultimate benefits than would result from alternative uses of the same labour input. This interpretation hardly suggests that labour productivity is a good proxy for all factor productivity, especially in the short run.

The computation of labour productivity indexes does not imply that labour is the only relevant factor, the unique and universal 'standard of value'. Such an index must, therefore, not be interpreted causally. It reflects, at best, the average productivity—not the marginal productivity—of labour in a sequence of static equilibrium situations. But a precise economic interpretation is unwarranted, even where labour's net product can be formally computed.

Under modern conditions, changes in labour intensity are not of decisive importance in explaining the movements of labour productivity indexes. Thus fluctuations in the degree of capacity utilisation, due to physical conditions like power failures or economic conditions like market sluggishness, are very pertinent. *In the long run, the change in technology (through entrepreneurial initiative, competition, pursuit of military security etc) is decisive in raising the productivity of current labour input.* To attribute the longterm rise in manufacturing output per manhour to labour effort would make as little sense as ascribing the gain in farm output per horse to greater *equine* effort.

What we have just said is probably not so often misunderstood as popular business literature may imply. American labour leaders do not claim that labour effort and labour productivity are historically correlated. They seek wage increase on vague moral or ethical grounds of entitlement to a fair share in the *joint* national productivity dividend; or on *Keynesian* grounds that the prosperity of all is ever endangered by the threat of underconsumption. The AFL's *social* wage demand of the 1920's and the more recent CIO discovery of the *annual improvement factor* were not inspired by some vulgar version of the labour theory of value. It might also be observed here that neither Marx nor his Russian communist successors (like Lenin and Bukharin) confused intensity of labour effort with the productivity potential of a technological-cultural State.

The usual productivity indexes must be distinguished from measures derivable from econometric equations involv-

ing production and one or more elements of input. The values for different periods do not represent conceivable alternatives for a given resource situation; they are historically discrete. On the other hand, differentiable mathematical functions of production and input (e.g. Cobb-Douglas or other regression equations) permit the calculation of what at least formally resembles marginal productivity. Such functions imply the interconnection of the whole sequence of time periods in a known manner. They may allow for a systematic change in the productivity level through the introduction of time or the treatment of cumulative output as an explicit variable.

A general commonsense definition of a concept like productivity admits numerous measures. That is, the pre-operational meaning of a broad term is compatible with many operational meanings. If the requisite data are available, then many measures are constructible. All these measures are conceptually satisfactory in the absence of a closer specification of purpose or use.

The definition of productivity as output per unit of composite input or per unit of labour does not imply a unique production concept. It says nothing about the preferred breadth of product or input classes, units of measurement, formulas and weights. If constructible, each alternative productivity index would make sense, in that each would have its special validity and be algebraically most appropriate to some definable context. The maker and user would then be able to pursue *pas la couleur, rien que la nuance.* The measure best satisfying advance specifications would be best for its particular use but not for any other closely defined situation.

Although a productivity (or any other) index ought ideally to be constructed in accordance with a purpose, limitations of available data preclude such a luxury—also the attendant intellectual responsibility. Not only are the practical alternatives severely restricted, but *compromises and improvisations are necessary.* The problem of the conscientious index maker or user becomes largely the recognition of the difference between what a particular context ideally requires and what is actually constructible or available. Such a conscientious student might also be concerned with the implications of settling for *the poor best that could be done.* For example, he might hazard a guess as to whether the actual measure is higher or lower than the one preferred.

An illustration of the frustration now experienced by the meticulous maker or user of productivity index numbers is the general unavailability of data for constructing a direct productivity index for a manufacturing industry. Such an index of the aggregative type with production weights is necessarily an internal average of the individual productivity relatives. It may also be rewritten as a ratio of a quantity index (with unit-labour requirement weights) and the labour input measure. The alternatives which have to be used for individual manufacturing industries are ratios of quantity indexes with unit-value weights and the corresponding labour-input measures. Since the unit values are unlikely as a rule to be proportional to unit labour requirements, the results may be quite different from those yielded by the preferred direct indexes. Indeed, the results need not be internal means of productivity relatives. They may be shown to equal in general the product of a desired direct index and an extraneous index reflecting the change in output structure.

Finally, *the arbitrary, conventional character of productivity and all other*

historical indexes must be acknowledged. Makers and users should be aware that *all such economic measurements, useful as they are, rest upon weak theoretical foundations.* Historical index numbers are bases on economic data, but they do not therefore reflect economic choice. They are *atomistic* in Frisch's terminology, rather than *functional.* They do not reflect the comparison and ordering of two or more states by a welldefined person or collectivity acting in accordance with the familiar principles of economic rationality. Data wrenched out of their original (presumed) equilibrium situations and recombined in some other way in indexes are deprived of their original contextual significance. The indifference or substitution map which describes the behaviour of the mythical decision-maker underlying a typical aggregative index is only a caricature of the kind of map discussed in economic texts. Our *demon,* being oversimple, is much too presumptuous in attempting cardinal, rather than ordinal, comparisons; in asserting how much better or worse the situation in one period is than the situation in another.

Certain conventions of labelling are misleading. Thus, a so-called measure of 'physical volume' of output is not physical at all. The weights applied to the gross production quantities in a typical aggregative index are usually money prices or unit values, and these weights convert the quantities into a particular kind of *homogeneous* rupees. If unit labour requirements could be used as weights, the quantities would be converted into *homogeneous* manhours. If unit labour added weights could be isolated for use in a net output approximation, then these aggregates too would be expressed in money. The same is true of the numerator and denominator of a conceptually more suitable index of net output, in which the weighted quantities are first reduced by similarly weighted inputs of materials, purchased energy etc before formation of the quotient.

Another careless statement is that the use of, say, the same price weights in the numerator and denominator of a production index *eliminates* the effect of price changes. Of course, some of the effects remain embedded in the very quantities. We also know that, even if the price level had not changed over time, different quantities would still be associated with different prices along a given demand or supply curve.

A most common error is the identification of the time base of an index with the weight base. Thus, the mistake is often made of asserting that the aggregates in a production index constructed on the base 19—=100 are expressed in "19—rupees" whatever the actual formula. Furthermore, the translation of a time base is incorrectly said to convert the aggregates into rupees of the new time period. Finally, the result of deflation of value index by a price index is frequently misrepresented as a quantity measure expressed in rupees or a common time base, whatever the formula of the deflator. All these errors show an unwarranted indifference to the fact that differently weighted quantity or price indexes need not be identical or even close.

Returning briefly to the meaning of a production index, we may ask: if it does not compare *physical* magnitudes, what does it measure? Although production has the object of creating utility, an index cannot be said to compare cardinal utility sums. The operational implication of a definition like *net output content* is unclear. A notion like *value added in constant rupees* at first may seem quite satisfactory. Deflation is a deceptively simple technique for deriving production indexes when quantity data are not available or when the products are very heterogeneous.

One of the *cliches* of the literature of production measurement is that the indexes have a *downward bias* due to persistent improvements in quality. But such a statement often conceals the natural prejudice of a latter-day observer in favour of the particular course history happens to have taken. *Secular deteriorations of quality are seldom* noted, and even then they may be rationalised as improvements after all.

Incidentally, the acknowledgment of unmeasured quality change as an unfortunate omission tends to reinforce the view that a production index does not portray physical volume. Furthermore, where such change occurs, a special burden is placed on the price index used in deflation—for this index must not only conjure up a meaningful, stable product frame but also in so doing must convert quality change into quantity change. Finally, it is curious that in the construction of productivity indexes, no reference is made to possible *bias due to neglect of differences in labour skill and quality.*

The basic production data also suffer from discontinuities other than quality change and from incompleteness of reportage. New products are introduced, some old ones die or *just fade away,* and product classes are continually being redefined. New and minor products of an industry are commonly reported, not by quantity, but by value and also in combination. *Assumptions and ingenuity take the place of data* as chain indexes are worked up, as value —and employment-coverage adjustments (of the Mills-Fabricant-Devons variety) are made etc. The algebraic implications of these techniques require close scrutiny and their validity should be empirically tested whenever possible.

It is probable that chain indexes and value adjustments for coverage tend to understate the rise in output of at least the USA. The chain index records no rise from zero for a new product. The value-coverage adjustment implies the similarity of price movements for directly measured products and for other products. But this assumption appears unjustified if the products reported by value only are new; their prices decline as a rule with respect to the prices of established, directly measured products.

For periods characterised by significant change in the product universe, more attention ought to be given to the *free-composition* index as a substitute for the chain index. The former is the logical extension of the straightforward fixed-base aggregative formula. In addition to products made in both the base and comparison periods, it includes products made in either (i.e. new or dying). Before introduction, a product has zero quantity; a defunct product also has zero quantity. If a Laspeyres formula is used with an early base, then numerous synthetic weights must be introduced for the many new products. These weights, corresponding to null quantities, would tend to be rather high. If a Paasche index could be constructed, then the problem of artificial weights for new products would be avoided. This index could be derived by deflation of the value index by a Laspeyres free-composition price index which likewise involves no artificial entries.

The concept of free-composition indexes can be applied, of course, to measurement of other entities than production and prices. In principle, it could be employed in the construction of a direct labour-productivity or unit-labour-requirement index. A Laspeyres measure of the latter could be derived by deflation of the labour index by a Paasche free-composition output index. Neither the Laspeyres measure nor the Paasche output index would require fic-

tional weights for new products. Another application is to the very problem of quality change. An item which changes drastically in its relevant attributes may be treated like a new product having a new weight. The old form has zero quantity in the period of change, the new form has zero quantity in the (early) base period.

At this point, mention should be made of another novel approach which may overcome various measurement problems: the *subproduct* approach. A subproduct is a well-defined, more or less homogeneous, operation, activity, or result corresponding to the arc of a longer process cycle. Thus a typical gross or end product of an establishment's entire activity is really a sum of sequential subproducts. If so regarded, then only the work done is counted during a period, whether the gross product is completed or not. The subproduct method would thus yield production indexes which are closer homologues of input indexes; more validly reflect activity where the process cycle is long compared to the measurement period; and tend to be invariant to changes in the degree of technical integration of establishments. It provides the theoretical key to a hierarchy of consistent production and productivity measures ranging from the job and department through the plant and industry to the national economy. It could also be useful for measurement in instances of extreme heterogeneity and instability of final output composition: subproducts may have less variability over time, and some are common to many end products.

For the time being, subproduct data are scarce. But compilation of such data will become more common as the notions of 'unit processes' and 'unit operations' spread from chemical engineering to other industrial activities; as the Leontief—Evans input-output technique and linear programming prove their practical value; and as the 'automation' and 'automatic factory' movements advance. Firms and governments will be disposed to recast accounts and statistics in terms of subproducts as technology progresses. The increasing variety of endproducts will tend to be reduced to multiples and complexes of a comparatively small *alphabet* of elementary standard of unitary processes or effects.

If we wish to define consistent productivity and unit-labour-cost indexes we should start afresh with the verbal identity: payrolls index=productivity index $\times$ unit-labour-cost index $\times$ labour input index; and proceed to implement it algebraically.

This opens the door to some important generalisations. Multiplicative identities involving more than two indexes (and hence having more than two elements within each weighted aggregate) show the importance of consistency in algebraic as well as verbal formulation. They indicate the nature of valid deflation, whatever the number of entities. They permit extensions of the time-reversal, factor-reversal, and other formal index-number tests. If the geometric mean is taken of all the algebraically consistent statements satisfying a verbal identity, the result is the generalisation of Fisher's "ideal" index. In the case of three entities, six such statements may be written, and each generalised "ideal" index is a sixth root. We have *data troubles enough, of course, in our usual two-dimensional index-number world.* Knowledge of the demands of higher space should provide some comfort as well as necessary theoretical perspective.

Since every Laspeyres or Paasche quantity index, whether it refers to input or output, may be regarded as the result of a proper deflation, a productivity index may be written as a ratio

of appropriate "price" indexes. Thus, a labour productivity index derived from gross output is the ratio of indexes of the gross value productivity of labour and product price. A gross productivity index referring to all cost inputs (factors, materials, etc.) is equivalent to the ratio of a cost index to a gross-product-price index. A net productivity index comprehending all current factor input (value added) is a ratio of a factor-price and product-price-margin indexes. Expressed in the form of such ratios, productivity indexes tell us that the impact of technology etc. is to make output cheap compared to input; to make utilised resources in the guise of output cheap compared to utilised resources in the guise of input. Since labour in the broad sense of man's participation in productive acts is the 'first price' of all things, then we may see again how the struggle against nature literally aims at making human effort 'expensive' compared to nature's yield.

Finally, a word about partition formulas which may be computed to reveal the "independent" contributions of changes in productivity etc. to the total change in, say, employment or value added. First, it must be noted that the conventional methods of estimating 'technological displacement' in the 1930's were too pessimistic; they allowed to offset in the form of market expansion as productivity itself advanced. Second, the attempt to isolate 'pure' effects is economically artificial though of statistical interest. Third, if all calculations of change are made from a common time base, then 'joint' as well as 'pure' effects arise. The mistake is commonly made of combining a joint effect with a pure—and in such a fashion that the explicitly recognised variables are not affected symmetrically. Fourth, the mistake is sometimes made of attributing joint effects to 'other' residual variables not explicitly re-organised in the partition. The impropriety of the assymmetrical treatment of recognised variables or of the introduction of extraneous explanatory variables becomes evident when it is recognised that all the effects are simply the terms of a Taylor expansion of a sum of functions of 'independent' variables with zero remainder. Fifth, when we have only two variables (e.g., when we break a change in labour input into effects of changes in unit labour requirements and production), a partition formula may be set up which symmetrically distributes the joint component between the other two. In the case of more than two variables, no compromise partition formula involving only symmetrical additive components seems to be definable.

Although this article has dwelt largely on errors of practice and on theoretical requirements which may not readily be satisfied, its intent is constructive. It seeks to direct the attention of index makers and users to the opportunities for improving concepts, data collection and methods; to *the opportunities which lie outside the ruts of convention and complacency.* A favourable attitude toward experimentation must be developed, toward *even the crude implementation of* advanced theoretical ideas.

Towards a Common Measure of Productivity

HAROLD W MARTIN*

Of recent years input-output analysis based on applications of the Leontief matrix have been suggested. One such application advocates inclusion of materials in the input and output. The inclusion of such throughout factors in productive efficiency ratio is challenged by LA Maverick on the ground that "production consists in adding value to the materials" and it is the efficiency with which this value is added that is the subject of productivity measurement.

THE apparent defect in many, if not all, of the methods of productivity measurement so far developed seems to be that they do not provide a basis for precise measurement of the productive work which alone can directly generate the output. A necessary prerequisite to such precision of measurement is the identification of the activities which, in any given case, constitute productive work in terms of the end-objective of the organisation whose productivity it is desired to measure.

A preliminary application of this type of productive work concept to the measurement of the productivity of a civil engineering design organization recognized only drafting work and lettering work (whether done by hand or by a varityping machine) as productive work in terms of the ultimate objective of the organization, that is, to produce drawings and plans of bridges and highways. This then was the (productive) work which generated the organization's output and was therefore used, when measured as to its amount, as the output index. The output index, converted into a productive work cost, divided by the cost of all the work done in the organization—the productive work plus all the supporting (non-productive) work during a given period, provided a comprehensive measure of the productive efficiency of the design organization. The resulting productivity index could be compared validly with productivity indices, developed in the same manner, for any other engineering design organization, civil or otherwise.

A unique feature of this approach to the measurement of productivity is, perhaps, that the output is directly related to the amount of time that the potentially productive facilities (per-

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sonnel and equipment) are in fact found to be performing productive work, using the momentary work sampling method developed by TIPPETT as the means of determining the productive (to nonproductive) work ratios. Specifically the suggested method normally involves

a) Determining the cost per (fixed asset) unit of potentially productive equipment per normal unit of work time, by rational apportionment of all non-productive personnel costs and overhead expenses to the potentially productive fixed assets. b) By work sampling, determining the productive (to non-productive) work ratio for each potentially productive unit (personnel and equipment) for a given period c) Determining the evaluated work productivity, or evaluated productive efficiency E, for the entire establishment (or any appropriate section thereof) for the given period from:

$$E = \frac{\sum_{m=o}^{n_m} C_m \cdot P_m + \sum_{w=o}^{n_w} C_w \cdot P_w}{\sum_{m=o}^{n_m} C_m + \sum_{w=o}^{n_w} C_w}$$

where :

- m = a potentially productive fixed asset (unit of equipment)
- w = a potentially productive worker
- C_m = cost per (fixed asset) unit of potentially productive equipment per normal unit of work time
- C_w = cost per potentially productive worker per normal unit of work time (productive worker wage rate)
- P_m = productive work ratio for a potentially productive unit of equipment (over the given period)
- P_w = productive work ratio for a potentially productive worker (over the given period)
- n_m = total units of potentially productive equipment
- n_w = total of potentially productive workers

The apportionment of overhead expenses to the potentially productive equipment is a convenient but logical convention by which due proportions of the operating costs for an organization are introduced into the output (numerator) and input (denominator) of the suggested productivity model.

In certain cases, the organization, or section thereof, whose productivity it is desired to measure is not dependent on equipment for its output to a significant degree—such as, for instance, in a selling organization or certain clerical sections of industrial organizations. Consequently, the normal method of productivity measurement described heretofore has to be modified, in such cases, with respect to the convention for introducing due proportions of the operating costs of the organization or section into the productivity model. The specific method suggested for the measurement of productivity in enterprises in which equipment does not perform a significant proportion of the work identified as productive in terms of the end-objective of the organization, would only mean the substitution in the formula of cost per potentially productive person for unit of potentially productive equipment as shown below:

$$E = \frac{\sum_{w=o}^{n_w} C_w \cdot P_w}{\sum_{w=o}^{n_w} C_w}$$

Selling organizations are peculiar in the respect that the productive work which specifically accomplishes the ultimate objective of the enterprise—the demonstration of merchandise, and|or explanation of the features thereof, to potential customers—can only be done when a customer is available who will cooperate, so to speak, in the productive work process. Consequently, the degree

of availability of potential customers tends to be an important factor when comparing the relative productivity indices of different periods for the same selling unit or of different selling units or organizations.

The cooperative nature of this work identified as productive in terms of selling also leads to recognition of the fact that sales personnel of necessity must work at any given instant in one of two basic environments. The first of these is a potentially productive environment in which at least one customer is present to whom merchandise can be demonstrated. The second is a non-productive environment in which no customers are present. A realistically designed plan for measuring sales productivity consequently needs to provide for measurement of

a) The degree of customer availability in each selling unit whose productivity is to be measured b) The productive to non-productive work ratio within the customer present environment for each selling unit c) The ratio, time-wise, of the customer present environment to the customer absent environment for each selling unit.

The measurement method

The work sampling method provides an ideal means of providing for productivity measurements through the recording and analysis of randomized momentary observations of the productive or non-productive work status of each unit whose productivity is being measured. Some of the advantages of using this statistical sampling method of data collection and measurement are

a) the observations, being momentary and at random intervals, are relatively innocuous, do not tend to disturb the normal performance of the activities whose degree of occurrence is being measured, and can therefore reasonably be applied to all types of activities, whether performed by equipment, by manual workers or by clerical or professional personnel b) because the method of observation, when properly done, approximates the degree of random observation of personnel applied normally by a good supervisor, the sampling data can be collected conveniently by the supervisory staff without adversely affecting its ability to perform its normal duties. In fact, there is evidence to support the supposition that such data collection may improve the quality of the supervision. Consequently, it appears possible for continuing productivity measurement of this type to be based on routine samplings done by supervisors, thereby providing the basis for constant appraisal by management of the productive efficiency of the organization or section c) The process of data collection can be continued until it provides any desired degree of precision so far as the accuracy of measurement is concerned. Conversely, the accuracy level generated by any given body of collected data can be calculated precisely by the use of the appropriate methods for determination of the standard deviation from sample means.

The productivity quotient E, can provide a measure of the productive efficiency of any organization or any appropriate section thereof in terms of the proportion of the total (input) cost of operating the unit which is, in fact, actually productive (output). This is based on the (logical) assumption that the operating costs for facilities (such as buildings, equipment, power, etc.) and the non-productive (manufacturing and/or staff) personnel are incurred to support the particular (productive) whose productivity is to be measured and that, therefore, the proportion of total potentially productive time actually spent doing the work identified as productive—in terms of the end-objective of the activity—is a measure of the proportion of total (input) operating costs which produces output in terms of the ultimate objective of the enterprise. In effect, this is based on the assumption (deemed to be logically valid) that the actual output—such as the average value of the products sold by an industrial or commercial enterprise—is proportional to the time spent on productive work.

Labour Productivity Under Indian Conditions

AK Bose*

Industrial processes in India are generally manual intensive compared to a like-to-like product abroad, especially when compared to West Germany, USA and UK. *Although great scope for mechanisation exists in many facets of industrial work in India, it is still cheaper to employ labour and/or only partly mechanise in order to maintain accuracy of workmanship.* Abroad the conditions are logically reversed as with high man-hour rates more and more mechanisation is called for, coupled with the problem of shortage of skilled hands especially in West Germany.

DIFFERENCES IN RESOURCE-ENDOWMENT of various countries are a compelling reason for a significant variation in the employment of productivity technique. Convincing evidence of this state of affairs can be obtained by a glance at the table below which analyses the man-hour rate to machine-hour rate in the USA and West Germany compared to India. For purposes of this analysis, only the factor of obsolescence connected with depreciation has been reckoned, that is to say, it is assumed that in 10 years the machine would be practically obsolete and would fetch very little price due to vast strides being made in the technological advancement in machine tool manufacture. In short, the analysis serves to compare what it costs management to keep the machine idle for one hour abroad and in India respectively when matched with the man-hour costs in the two countries. It can also be said that a proportionate maintenance cost of 1% for idle machines has been reasonably assessed, as whether the machine is used or not, necessary preventive maintenance has to be carried out like cleaning, oiling, etc.

		West Germany	*U.S.A.*
1	Cost of representative general purpose milling machine	64,000 Marks	24,000 Dollars
2	Obsolescence depreciation/hr (10 years period)	3.20 „	1.25 „
3	Maintenance of idle machine (1% of cost/annum)	0.03 „	0.01 „
4	Interest lost on capital at 5% per annum	1.60 „	0.63 „
5	MACHINE-HOUR RATE	4.83 (Rs. 5.3)	1.89 (9.4)
6	MAN-HOUR RATE	3.40 (.75 Np)*	3.00 (.75 Np)*
7	MACHINE HOUR RATE / MAN HOUR RATE	1.44 (7)*	0.63 (12.4)*

* In India.

* Chief Industrial Engineer, Hindustan Aircraft Bangalore

It can be seen that even for machines with half the capital cost analysed in the previous table, it would cost Indian management about 3½ to 6 times to keep one machine hour idle when compared to one idle man hour, while in West Germany and United States, the emphasis of control should logically shift to the man hour in preference to the machine hour. Thus conditions in industry warrant machines to be fully utilised. Greater attention has therefore to be paid to the following factors of control (a) absenteeism of operators (b) machine breakdown (c) power failure (d) avoidable idle time due to imbalance between machines (e) machine down-time due to improper tools, tool breakages and blunt tools.

The emphasis on proper planning

Each factor mentioned above is connected with Planning. No pains should be spared in order to plan the best way possible with the aid of charts, diagrams, formulae, operations research techniques, etc, and therefore Indian excutives connected with planning, maintenance and tool engineers, should be specially qualified and able if *prima facie* Indian labour productivity has to be raised to a satisfactory level. *What is required in India is not so much the immediate necessity for speeding up of pace of the Indian worker in order to catch up with the level of labour productivity abroad, but to try and obtain better utilisation of men and machines through proper planning.*

Under proper management, labour productivity in India is as good as its foreign counterpart. Hot climate has a limited, say up to 15% adverse effect on output for most types of factory work. This finding is supported by the fact that labour productivity in the hot southern states of the USA is measurably less than in the temperate north. The inference is that productivity is independent of race and power of muscles, as the normal or standard productivity in terms of internationally accepted standards is based on such a rate of work that can be comfortably managed without feeling unduly tired at the end of the day.

A problem of heritage

The productivity of Indian labour is generally low. The main reason is because Indian labour has been allowed to do only say three hours work in the eight-hour day against foreign labour utilisation of five to seven hours in the eight-hour day. This state of affairs can be traced right back to the days when the science of work measurement was practically unknown in this country and hence a state of equilibrium was reached between what the supervisor thought was normal output and what the worker was prepared to give as output under those conditions. In spite of low productivity and breakdowns in the flow of materials and processes, it was still cheaper to produce and bring in reasonably high dividends to the share holders. Added to this malady, which is largely hereditary, is the practice in India to fix the quota of leave (leave entitlement), a good portion of which, especially in the industries in the public sector, lapses, if not availed of before the end of the fiscal year.

Absentee reserve and productivity

In order to provide for uninterrupted work, Indian management in the public sector has to provide for atleast 13 to 15% absentee reserve, in other words, to employ a 13% to 15% larger task force. Taking the industry as a whole, the Indian industry therefore starts off with a handicap of say, 10% lower productivity per capita of Indian labour as compared to foreign labour.

Emphasis on wage incentive plans should therefore truly shift to controlling absenteeism which itself would

render the possibility of saving some 10% cost in wages alone leaving aside subsidy for transport, canteens and other reduction in overhead costs. It is an unfortunate experience that with the introduction of the Employees' State Insurance Scheme, absenteeism in industry is ever on the rise. At this juncture it must be recognised that one way of controlling absenteeism is to provide for powerful wage incentive plans that will *encourage the worker to want to earn more* and hence discourage him to stay away from work.

Domestic problem

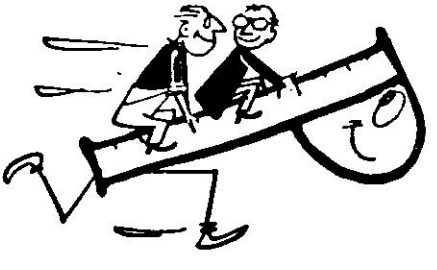
Although sociological and ideological drives are doing much to raise the domestic conditions of the Indian worker, they still leave much to be desired in order to ensure *that the "whole man" goes to* work and hence puts his whole heart and soul in his work, but it is clear that unless productivity improves, domestic conditions of the Indian worker cannot improve unless we are prepared to face unprecedented inflation.

Incorrect estimates and historical data

An important point often overlooked while discussing labour productivity is that many times the state of low productivity is brought about in Indian industries due to lack of necessary attention to proper estimates of the forecast of work in terms of standard productivity. This condition in turn is brought about by the use of improper standards or guess-estimates and hence the task force hired is often too large, which is not detected readily as labour begins to adapt its pace of work relative to the size of the task force so as not to show up idle time. If the foreman sees day to day that his men are working he is satisfied that his estimates are correct and next time any expansion of activities is contemplated, he has a tendency to use past figures which merely perpetuates the error often cumulatively and brings down productivity to an incredibly low level. Necessity therefore arises to develop proper standard data for operations and correct estimates as to how much to allow for other factors in order not only to ensure that standard task force is hired, but to make the first beginning to set right the level of low productivity through this technique alone in course of time.

It is thought that the non-incentive productivity of the Indian worker is about 40% less than that of the foreign worker. Due to the fact that there is considerable unemployment in India and our industrial man-hour rates are possibly the cheapest in the world, *competitive pricing should be logically based on labour intensive processes at a satisfactory level of productivity.*

Role of Labour & Management



Alternative Methods and Man-hours for Production

SEYMOUR MELMAN*

The dramatic rise of industrial productivity over the last half century is traceable primarily to transformations in the technique of production. In every type of industrial process, powered equipment performs work at rates that cannot be matched by the manual effort of any workman. At the same time techniques for organizing production have been evolved, enhancing the capabilities of powered equipment by integrating their operation. In fact, the fourfold increase in productivity of industrial workers in the United States over the last half century has been matched by a fourfold increase in the horsepower of the motor-driven machines which they use....The level of labour productivity has far-reaching effects. For the output of goods in relation to the input of production man-hours limits the possible supply of goods per person and thereby affects virtually every aspect of living.

THIS IS AN INQUIRY INTO WHAT HAS determined major differences in industrial labour productivity. How can we account for productivity changes in a given country over time? What factors can account for differences in industrial productivity that are plainly observable among major countries? The productivity changes that are dealt with here encompass the manufacturing industries. Within this area we are concerned with large productivity changes and large differences. With given production methods, especially those that are operator-paced, month-to-month productivity changes may be traceable to short-run variations in intensity of work, degree of plant utilization, quality of raw materials, and the like. We are interested, however, in the *changes of production methods* themselves. *They are the source of the large and lasting productivity* gains, for the character of production equipment and allied methods governs the potential output towards which other factors such as organization indeed contribute. Accordingly, we have studied the process whereby powered equipment has been widely introduced in industrial plants to replace manual work.

What determines the replacement of manual by machine methods in industrial production? Surely, it is not the mere existence of production equipment which regulates its use or non-use. Similarly, we know that it is characteristic of modern industry that things can be produced by a variety of available methods, requiring more or less manual work.

Decisions to use one production method in preference to another are necessarily social decisions. In industrial firms that are managed along business lines, such decisions are business decisions, controlled by the business re-

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quirements for competitive profit-making and extension of the firms' (management's) domains. Alternative methods of production involve alternative costs. Therefore, within the framework of business requirements, the selection among production methods turns on the costs of these methods.

Which costs are the relevant ones? The fact is that there are many elements of industrial cost and many ways and categories of viewing the outlays incurred by business management in the operation of industrial firms. For our problem of explaining productivity differences, the elements of cost that are most relevant are the costs of industrial manhours and the costs of machines that can be used to replace manhours.

The alternative costs of labour and machinery are our starting point. We do not attempt to treat the problem of how these are determined. *Both may be treated as commodities, production services purchased by management;* and that is how machine and labour costs will be treated here. (It should be noted however, that the view of labour as a commodity obscures the role of workers in altering wages and other production conditions. While we do not treat this aspect of worker behaviour, it is assumed to be operative in parallel with the trend of labour's manhour cost.)

The alternative cost of labour and machines can only affect the selection of production methods via the intervening process of management decision-making. Therefore, our interests include the characteristics of management's administrative, problem-solving routines. For the decisions on production design which control productivity levels are primarily the products of the management occupations. The problem of explaining productivity differences may thereby be translated as the problem of discovering under what conditions the management organisations of industrial firms are moved to order the mechanization of production methods.

In this connection, we may refer here to three related hypotheses on industrial labour productivity: the first is that the degree of mechanization of industrial work is controlled by the ratio of alternative labour to machine cost. This ratio has grown in a regular way in several industrial countries and that the size of the ratio accounts for the prevailing levels of mechanization. The second hypothesis is that labour productivity is governed by the degree of industrial mechanization. This obtains in various countries. Labour productivity is a direct function of alternative labour and machine cost. The third hypothesis is that the growth of administrative overhead in industrial firms has limited the effect of rising labour productivity on the output of goods per person. Facts, however, show that the growth of administrative overhead is not correlated with the rise of labour productivity and is traceable to the extension of management's decision-making.

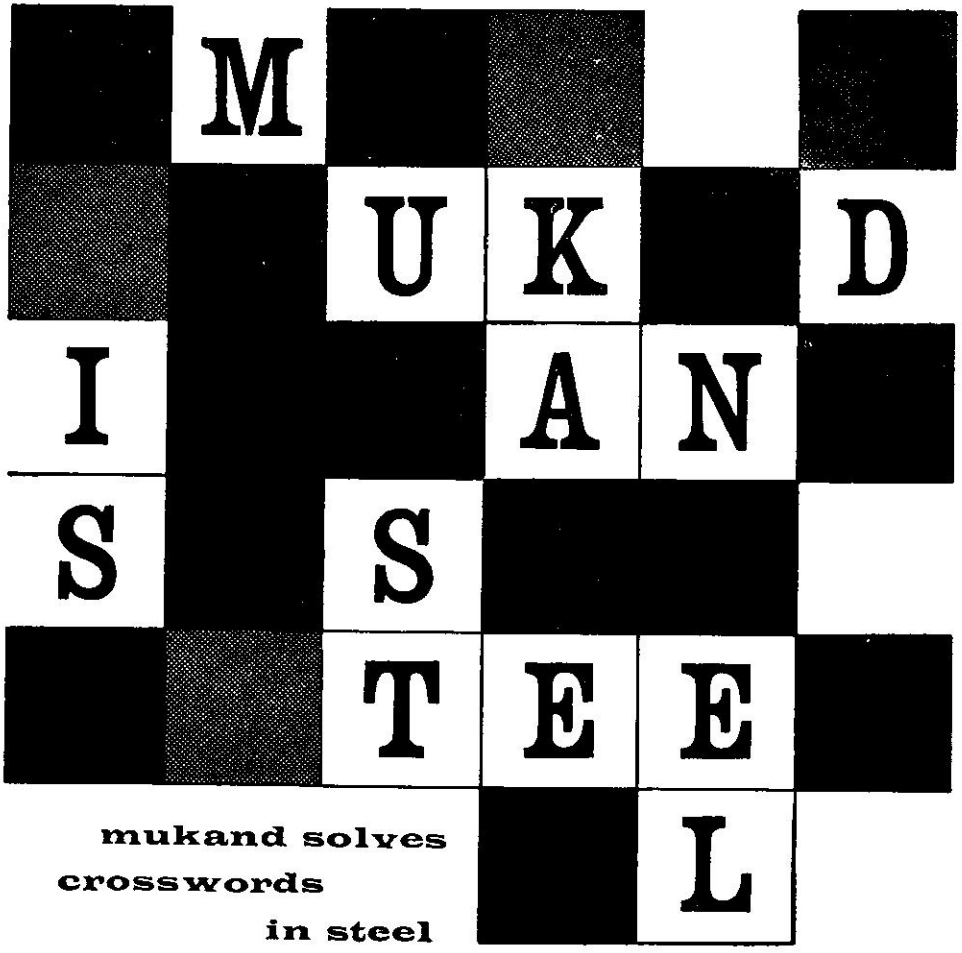
It has been suggested that other factors as well may have important bearing on productivity levels. These include geographical and climatic factors, institutional arrangements (cartels, methods of taxation), the extent and type of market, the size of industrial plants, systems of wage payment, standards of length of the work day and intensity of work and standards of nutrition. The fact is that these, as well as virtually every aspect of plant conditions, must have some effect on levels of worker productivity.

Our objective, however, has been to explore the extent to which the particular elements defined in our hypotheses as dominant, controlling factors do in fact account for productivity

trends. Therefore, while other factors have been kept in view, our major effort has been to define the effects of alternative cost and administrative overhead on productivity.

Since it is beyond dispute that *productivity is affected by as many elements as are involved in the production process,* how can one specify the main factors from among many elements which affect productivity? The modern view of inquiry includes the recognition of variability as a pervasive aspect of phenomena. In this study one problem has been to discover how much of the observed variation in productivity, at single times and over time, can be accounted for (predicted) by our hypotheses. A second problem is: how can one demonstrate the existence of a causal relationship between variables? The results of statistical analysis do not, of themselves, justify inferences of causal relations between variables. Thus the correlations which we have established between alternative costs, *production methods and productivity become significant summaries of causal relations only because* we have found that *these variables are connected by a definable pattern of managerial decision-making.*

Comparable methods of data analysis have been applied to problems ranging widely in the degree of manipulation which the investigator may impose on the variables being observed. Nevertheless, in every science it has been possible to develop predictively useful statements of relationship between dependent and independent variables, without detailed reference to a host of surrounding conditions. In this context, we need to explore the force of alternative industrial costs and the cost of managerial control as controlling elements in industrial productivity.



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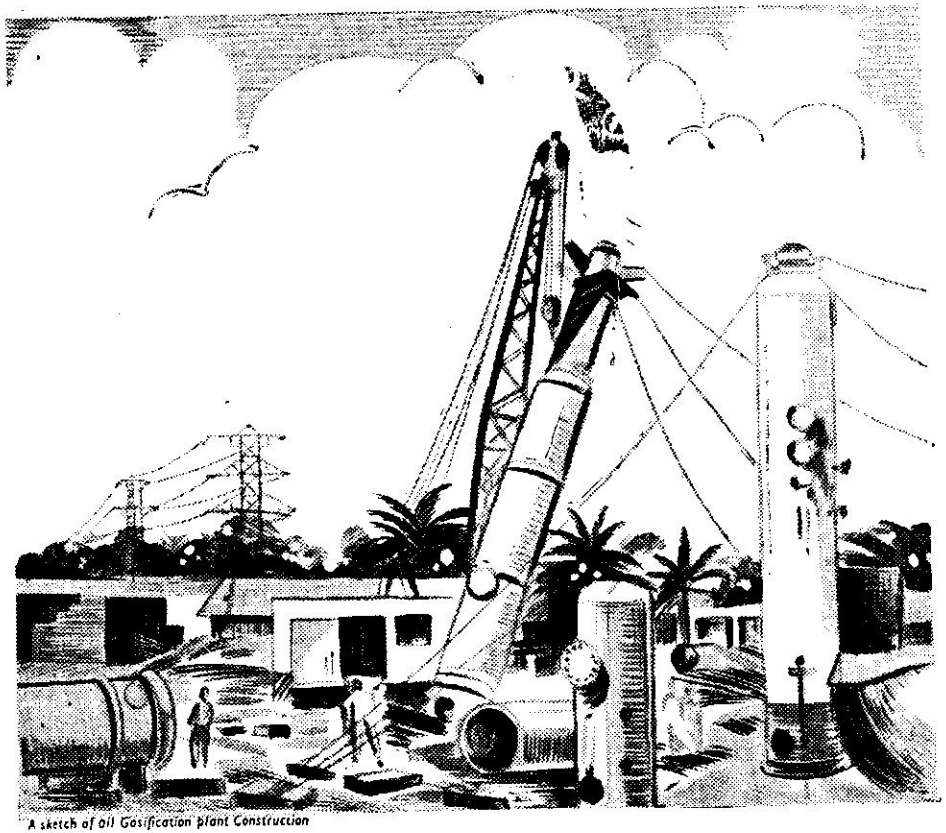

A sketch of oil Gasification plant Construction

The battle for India's economic freedom has to be won in her farms and factories. Though there has been considerable progress in both fields, there still remains much leeway to be made up.

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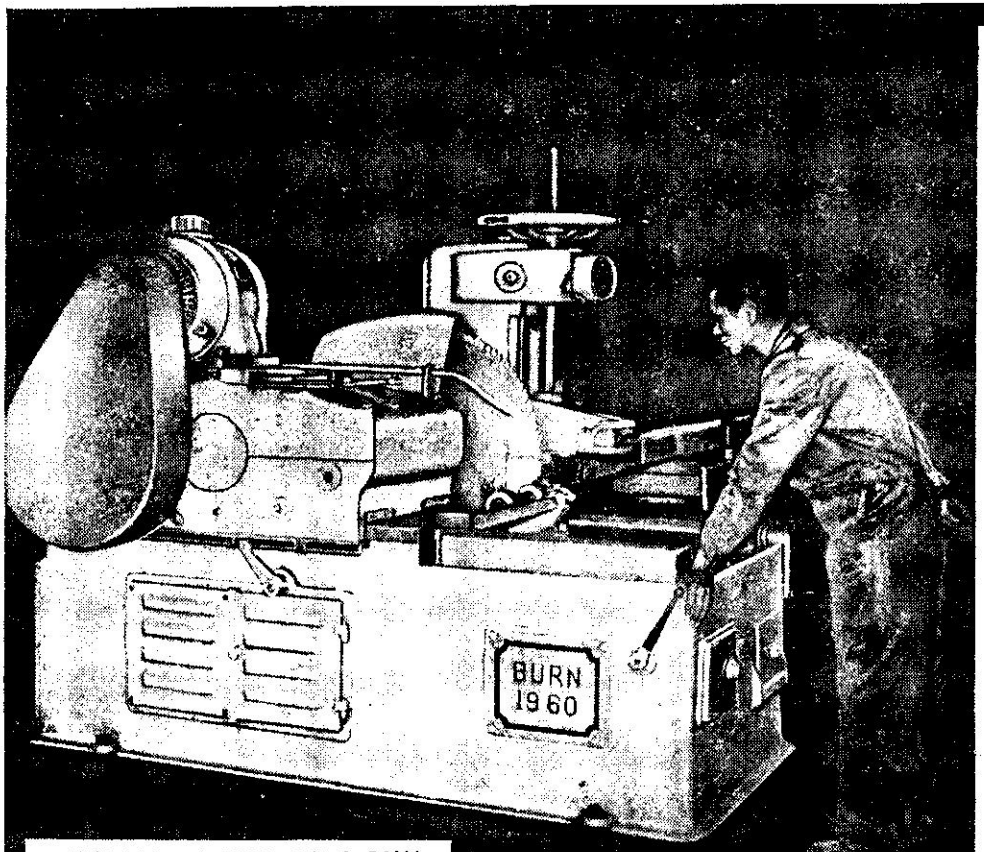

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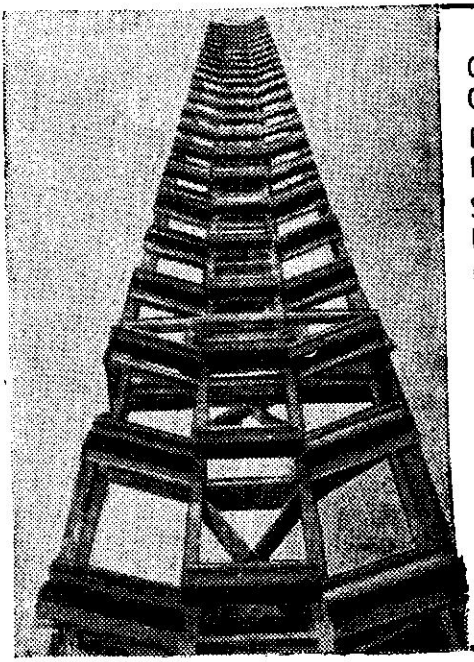

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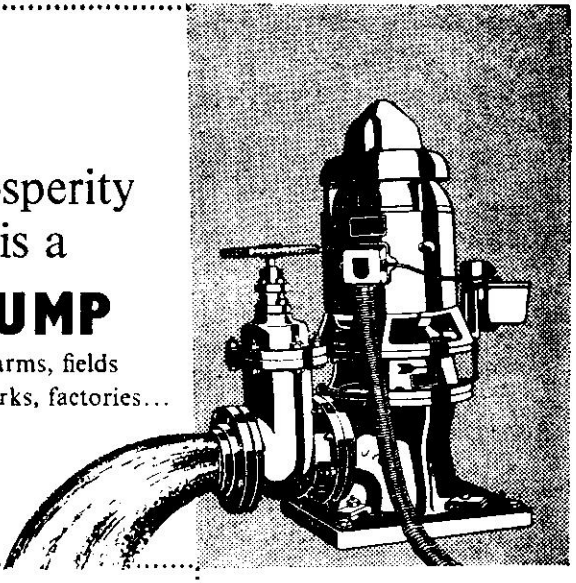

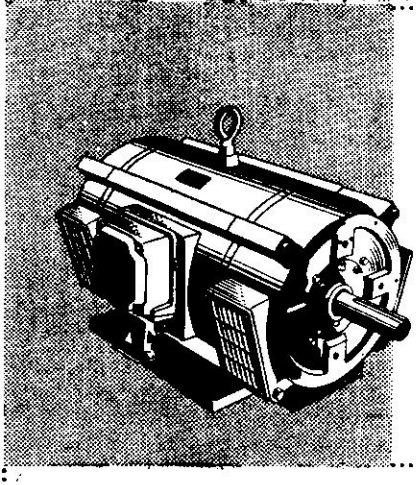

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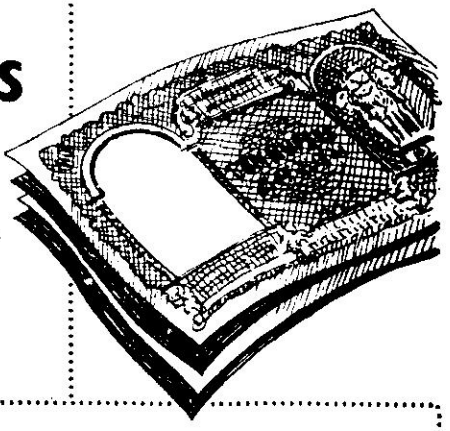

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Labour Productivity Comparisons

DEBORAH PAIGE AND GOTFREID BOMBACH*

The Organisation for European Economic Cooperation and the Department of Applied Economics, University of Cambridge made recently a joint comparative study of the national output and productivity of the UK and the USA; and they found that "for the economy as a whole, output per worker in the United States was about twice as high as that in the United Kingdom—213 per cent when weighted at British prices, and 175 per cent at American price weights. In manufacturing industry, for which a rather more precise content can be given to the concept of labour productivity, the American advantage is higher, the indices being 292 at British prices and 256 at American prices." The authors who undertook this expert analysis have analysed below the significance of these national labour productivity comparisons.

A CAUSAL ANALYSIS NEEDS TO TAKE account of the various factors determining productivity, and in time series one of the most useful methods of analysis has been based on subdividing these factors into three categories: labour, real capital and "technical progress". In this context, technical progress is a residual group covering all the remaining factors influencing productivity. Among the most important of these are the level of technology, types of organisation and management, the degree of standardisation of products, production control techniques, size of market etc. Various empirical investigations have been made, based on this analysis. Solow, for example, considered these three elements determining increases in total productivity, and found that, in the private non-farm sector of the United States economy, in the period 1909-1949, the growth in productivity attributable to technical progress alone was 81 per cent (about 1.4 per cent per annum).

In comparisons between countries at a single point in time the same three classes of factors are equally appropriate, but in international comparisons the residual group, corresponding to technical progress in time series, requires more careful consideration. Differences in natural resources constitute an important item in this group. In the comparison between the USA and the UK natural resource differences are the predominant factor in some of the nonmanufacturing sectors, and their effect, through variations in quality and cost of raw materials and fuels, is also important in a number of manufacturing industries. *Differences in historical, environmental and institutional factors also play a large part.* There remain, however, important differences in the level of technology, and organisation which are more difficult to explain between countries than over time, inas-

* The organisation for European Economic Cooperation (OEEC) Paris

much as the greater part of the technical knowledge of a particular period is available to all developed countries.

The main difficulty in an empirical application of this kind of analysis is that of finding appropriate comparable measures of the quantity of capital available in different countries. This difficulty has so far made a complete interspatial analysis impossible, but some rather general inferences can be drawn respecting the results of such an investigation. Various studies have shown the differences in capital|output ratios both between countries and over time to be surprisingly small. Larger real variations may, of course, be concealed by differences in price structures and in the definitions used, but it is clear that, at any rate for relatively developed countries such as the USA and the UK, the differences in capital|output ratios are extremely small by comparison with the differences in output per worker.

It would seem that, although output per worker in the USA is rather more than 2½ times that of the UK, output per unit of capital employed may be about the same in the two countries. Thus it follows that capital available per worker in the USA may also be about 2½ times that in the UK, but it would, of course, be *quite incorrect to argue from this that the higher productivity of American industry is attributable predominantly to a larger capital input.* The productivity advantage of the USA, related to both capital and labour inputs, would, of course, be below that shown by the simple output per worker index relating to labour input only. The important factor is, however, that owing to the various technological and natural resource differences, the combination of capital and labour employed in the USA has a higher productivity than the combination of capital and labour used in the UK.

Another factor that has provoked considerable discussion is the question of the scale of production. It has often been observed that over time, there is an *association between rapid growth in total output of particular industries and rapid increases in productivity.*

The causal factors here are obviously interrelated. On the one hand, increases in total production stimulate productivity both by enabling increased economies of scale and, as a result of an increase in the proportion of new plants, enable more use to be made of the most modern equipment and technology. On the other hand, increases in productivity must lead to an expansion of output through the effect of reduced costs upon demand. The connection between high relative productivity and high relative total production is also evident in interspatial comparisons.

It has been pointed out that it is difficult to determine how far high productivity is the result and how far it is the cause of high total output when making intertemporal comparisons. It is even more difficult to make this analysis when the comparison is being made between two countries at a single point in time. *Productivity is itself a major determinant in price,* and consequently, at least in industries entering international trade, high productivity in relation to wage levels is essential if the industry is to compete in world markets. On the other hand, in some industries large markets certainly afford opportunities for economies of scale. Measured by employment there is no marked difference in the average size of British and American firms. If, therefore, the productivity advantage of the USA is to a significant extent attributable to advantages arising from economies of scale, it would appear that these must be mainly *economies arising in the industries as a whole rather than in individual plants.* It has frequently been pointed out that individual American

manufacturers derive considerable advantage from increased specialisation on a smaller number of lines. This may be partly an economy of scale, in that *a larger market permits a higher degree of specialisation.* The advantage is also due, however, to a larger amount of standardisation of American manufactured goods which is a result not of larger markets but of more uniformity of product within the market.

values. This factor has often been remarked in inter-temporal comparisons, the most typical case being when, in the process of industrialisation, there is a movement of workers from agriculture to industry. In this case the change in the distribution of the labour force will result in a rise in aggregate productivity, measured in terms of net output per worker in base year prices, even if the productivity coefficients of the two

especially during the Second Plan period there has been improvement and in 1958 the value added productivity was higher than in 1948 by approximately 41% at current prices and 24% at constant prices.

It is interesting to note that about half of the total economic growth of the private economy of the United States during 1889-1957 is attributed by the National Bureau of Economic Research to productivity increase, the remaining half is accounted for by the growth of the factors of capital and labour themselves. Referring to the increases in world industrial output and employment between 1938 and 1953, the Statistical Office of the United Nations has recently stated that employment has expanded (37%) much less than output (95%) because of substantial increases in the productivity of labour. The annual rate of growth between 1938 and 1953 in output per person engaged in the world approximated 3% : 2% due to the increase in labour productivity and 1% as a result of shifts in the distribution of employment from less efficient to more efficient industries.

While overall comparisons of productivity between two different periods of time help in determining the variations in productivity, regional comparisons may throw light on the relative differences in their productive efficiency and profitability: a factor of some importance in planning the dispersal of industries. Bombay and West Bengal are known to be our most highly industrialised States. Roughly, their productivity rates (Rs 11.9 and Rs 10.2, respectively), based on value added per person per day, are higher than those of Madras (Rs 8.1), Andhra (Rs 8.3), Uttar Pradesh (Rs 7.8), Mysore (Rs 9.10), Punjab (Rs 9.4), Rajasthan (Rs 6.6), Assam (Rs 7.7) but smaller than those of Orissa (Rs 12.6) and Kerala (Rs 12.0) which are relatively much less industrially developed. The highest productivity rate, nearly twice that of Bombay and West Bengal, works out for Bihar (Rs 19.2).[2]

An inter-industrial comparison of productivity is also useful. On the basis of value added per person per day again highest productivity is noticed in soap industry (Rs 42.4), followed by paints and varnishes (Rs 25.6), vanaspati (Rs 23.0), sugar (Rs 22.7) and chemicals (Rs 20.8). Most of the industries including iron and steel, general engineering, cement and woollen, etc have varying rates between Rs 10 and 19. Quite a few industries including our oldest industries—cotton and jute textiles—have productivity rates below Rs 10.

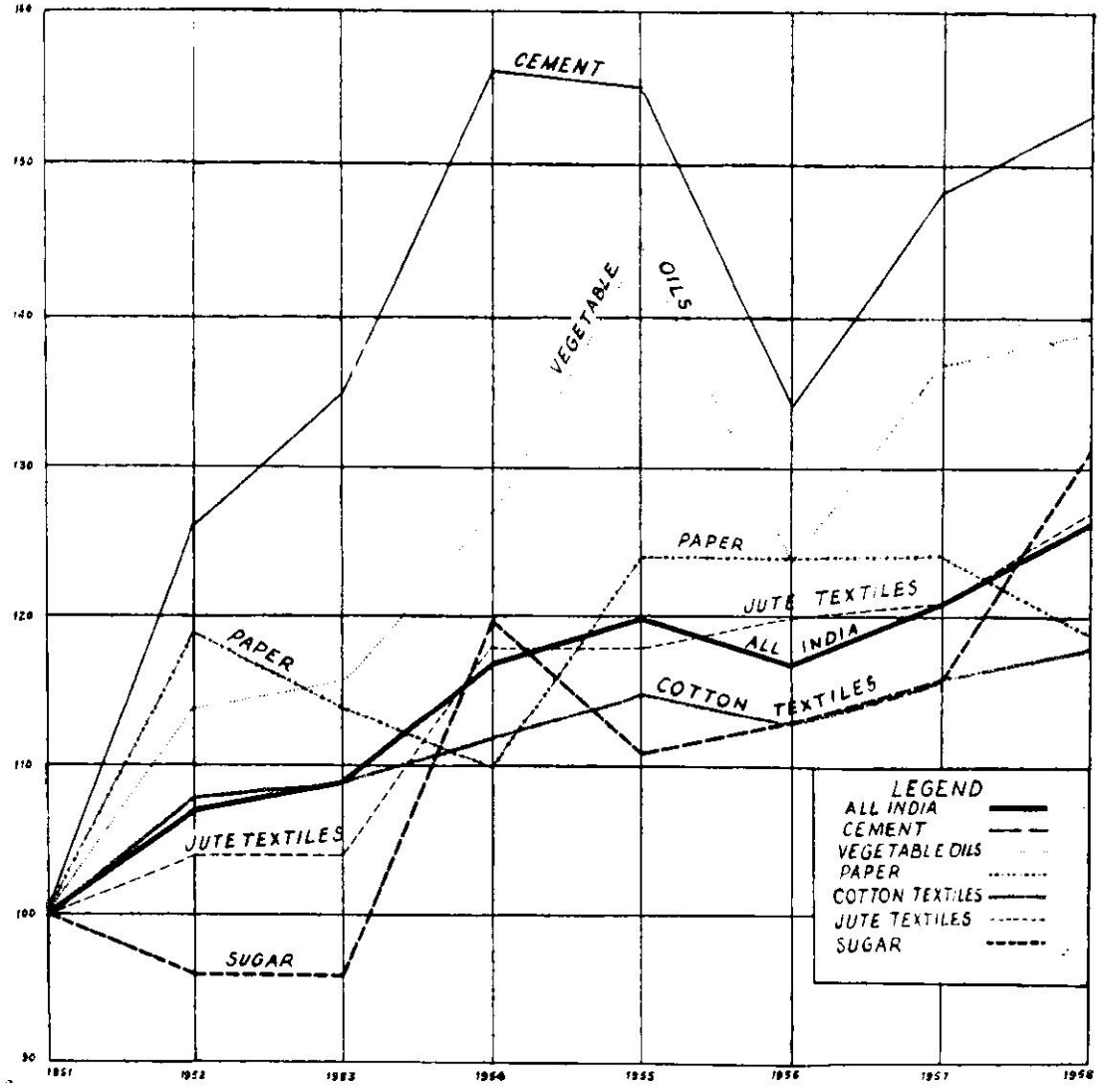
2 This figure has to be taken with a considerable measure of caution, as it most probably reflects the high degree of mechanization in the steel and cement industries located in Bihar (editor)

Index numbers of industrial productivity

1951 = 100

	1952	1953	1954	1955	1956	1957	1958
cotton textiles ..	108	109	112	115	113	116	118
jute textiles ..	104	104	118	118	120	121	127
sugar ..	96	96	120	111	113	116	131
cement ..	126	135	156	155	134	148	153
vegetable oils ..	114	116	127	145	124	137	139
paper ..	119	114	110	124	124	124	119
All-India (weighted according to investment) ..	107	109	117	120	117	121	126

*Productivity Trends in Six Major Industries**



* Statistical construction by Sri GK Nayar, senior economist and art work by Sri Vohra, artist and Sri Kundanlal, cameraman, NPC.

An Assessment of Productivity Increase

GK NAYAR

Having organised the productivity movement for more than three years, NPC has been naturally anxious to assess broadly the increase in industrial productivity since its establishment in February 1958. Several forces have been operating during this period including fresh investments, new enterprises, expansions both in the public as also in the private sector. This period is coextensive with the second half of the Second Five Year Plan. Hence it would be somewhat difficult to identify and isolate the factors that have contributed to increased industrial productivity during the period. However a broad appraisal had to be attempted in the public interest. Accordingly NPC addressed a number of industrial concerns requesting for basic productivity data which would broadly indicate the trend in productivity during the past few years. The response was encouraging, about 100 replies having been received. Of course the usual difficulties were encountered in the collection of the statistical data but nevertheless on balance, considering the preliminary nature of the venture the material has been considered as not insufficient for a preliminary assessment. NPC is following up the matter and more reliable conclusions will be presented in the not too distant future... Of the replies received it was found only 40 firms had submitted productivity data out of which the material of 31 firms could be made use of for determining the increase in productivity. A closer analysis led to the elimination of another 10 firms with the result that we are left with 21 firms for which the data has been calculated.

Though the number of firms is small yet the scrutiny made of the statistics has been thoroughgoing and to that extent reliable. The following table gives the percentage increase in the productivity of each of the 21 firms during the period 1956-57 to 1959-60. The firms have been listed according to date of receipt hence the presentation is statistically random. Productivity has been measured in terms of output per unit labour time. An increase of productivity indicates so much less time taken to produce a unit of the same output.

Number of the firm	% increase in productivity in 1959-60 over 1956-57
1	29
2	8
3	22
4	31
5	56
6	46
7	31
8	28
9	12
10	15
11	3
12	37
13	46
14	36
15	43
16	10
17	70
18	14
19	17
20	20
21	29

It is possible to re-arrange the data so as to show the increase in productivity ranging from 3 to 70%, also to show that quite a large number of firms are in the higher category. Actually the statistical data so far obtained would not warrant an absolute statement of that character. While it is true that this can reasonably be taken as a fairly representative sample, showing general increase in productivity over the whole range of industry and in certain cases very considerable, it would really be difficult to build a firm generalisation on this basis. A statistical average of increases recorded above has been worked out at nearly 29%. But it is again difficult to say whether this could be taken as the average increase in industrial productivity during the period under review. It may be added here that the industries covered by these statistics are sugar, confectionery, paper, cement, cotton, textile, chemicals, engineering, cycle, transport and printing. As supplementary to the analysis it may be pointed out that according to the reports submitted by the firms, techniques usually employed to increase productivity are the following in the order of frequency: (i) incentives schemes (ii) improved maintenance (iii) better layout (iv) training of workmen and managers (v) good human relations (vi) installation of the latest type of machinery. A few other techniques generally adopted to improve productivity are materials handling, methods study, joint consultation, and suggestion scheme. In some cases, increase of productivity has also been achieved by plant expansion, not associated with a proportionate increase in manpower.

* Senior Economist NPC

Productivity in Iron and Steel

A GHOSAL*

The iron and steel industry is a crucial industry for any country, particularly so for India which is rapidly undergoing transformation from a primarily agrarian to an agro-industrial economy. Low consumption of steel goes alongside a low standard of living. In the Second Five Year Plan, however, a break-through was planned by setting a production target for ingot steel at 6 million tons per annum by the end of the Plan. The Third Plan envisages an increase in the production of ingot steel to 10 million tons per annum by 1965-66. Since the inception of planning, the production of pig iron has nearly doubled from 1.68 million tons in 1952 to 2.99 million tons in 1959. The production of finished steel has increased by nearly 60% from 1.1 million tons in 1952 to 1.74 million tons in 1955. This article confines itself to a study of productivity in this industry of vital national importance.

WHILE MEASURING PRODUCTIVITY IN ANY industry we relate the output to the input either in terms of money or in physical terms. The output per unit input is a measure of productivity. It appears, therefore, that an increase in production is not necessarily accompanied by increase in productivity. In this article productivity is measured in monetary terms by three indices as follows: (1) rate of productivity which is a ratio of value added by manufacture to the value of input (2) value added per 100 man-hours (3) value added per capital employed. Arise in the above indices would show efficient performance of industry. In physical terms the rate of productivity for this particular industry has been gauged by the rate of consumption (in tons) per ton of pig iron produced. The steel industry consumes various ores: iron, manganese, chrome, limestone. The rate of consumption of each of these materials per ton of pig iron helps in projecting future requirements.

The following table gives the relevant statistics for calculation of productivity indices.

In crores of rupees

	Gross exfactory value of output	Value of output	Value added by manufacture	Productive capital employed
1951	61.1 (100)	34.6 (100)	26.5 (100)	56.4 (100)
1952	70.2 (115)	39.6 (115)	30.6 (115)	54.8 (100)
1953	72.5 (119)	37.7 (109)	44.7 (131)	62.5 (111)
1954	86.3 (141)	40.8 (126)	42.5 (160)	70.2 (124)
1955	93.6 (162)	40.0 (139)	42.6 (168)	77.9 (138)
1956	114.0 (187)	58.9 (170)	55.1 (208)	94.0 (167)
1957	117.2 (192)	65.8 (190)	51.4 (194)	120.8 (214)

* Central Fuel Research Institute, Jealgora

Every set of figure in the table printed above has been indexed in order to show the trend from 1951 to 1957. Taking the period as a whole, the number of manhours worked has risen by only 6%.* Indices of productivity have been calculated below on the basis of the statistics given in the table printed above.

The rate of productivity given in the last column has been calculated by dividing the value added by manufacture by the value of input and multiplying the quotient by 100. This rate of productivity has been further indexed to show the trend. Taking out 1957 as exceptional, due to some possible lag in investment and output at a critical stage of development, it will be seen that there has been a considerable rise in productivity, as indicated by all the factors analysed in the table printed above. It is true that two of the indices have since 1954 shown a slight falling trend but it is more indicative of a broad state of stability at a high level of productivity than of anything else and it is reasonable to presume that these trends have continued till date, though it is difficult to substantiate statistically as the Census of Manufactures is not available uptodate, but as the same factors—acquisition of higher skills by workers, training programmes for foremen and managers and extensive mechanisation —have been operative during the period, in fact on a more intensive as also on an extensive scale. There is another fact of very great importance, for upto 1957 the steel plants in the public sector were not yet commissioned for production.

	Value added per hundred manhours	Value added per hundred Rs. capital employed	Rate of productivity
1951	169 (100)	47.0 (100)	76.6 (100)
1952	203 (120)	55.9 (119)	77.2 101)
1953	239 (141)	55.6 (118)	92 0 (120)
1954	265 (159)	60.5 (129)	97.0 (127)
1955	276 (167)	57.3 (122)	93.0 (121)
1956	333 (197)	58.6 (125)	93.6 (122)
1957	310 (183)	42.6 (91)	79.1 (102)

Another factor which would have a bearing on productivity is raw material consumption, in this case the consumption of various ores: iron, manganese, chrome, limestone etc. It is interesting to find that the rates of consumption have been more or less constant over the period with the exception of manganese ore whose rate of consumption recorded high values in two of the years under review. It is possible that the changes in technological processes that are going on may significantly affect the rates of consumption of ores (with the possible exception of iron ore) and this would be a factor of major importance in the net productivity achieved in the steel industry. This would be of significance for the whole economy, for considering historical trends, we shall be having the steel age in India in the not too distant future.

* Since the productive capital has during the period more than doubled, this would be indicative of extensive mechanisation alongside a marked increase in labour productivity etc. (editor).

Productivity in Indian Cement

Cement being one of the crucial materials in economic development, the community is entitled to expect that the producers of cement are making the most productive use of the resources invested in the industry. During the last 11 years the installed capacity in the cement industry has increased from about 3 to 9 million tons. The current output is running at the annual rate of 8 million tons as compared to a little over 2-1 2 million tons in 1950. The capacity target fixed for cement during the Third Plan period is 15 million tons; and the Planning Commission expects on the basis of recent trends in demand that the cement target may have to be revised upwards; hence the vital importance of attaining maximum productivity in the cement industry in the public interest. Below is published an analysis of productivity in Indian cement industry, as published by the Association of Indian Trade and Industry.

PRODUCTIVITY IN THE INDIAN CEMENT industry as measured by the quantity of cement produced per manday or per manhour or the installed capacity or production per employee, was very low in India compared to leading cement manufacturing countries such as the USA, Belgium, Japan, the UK and West Germany. In 1957 installed capacity in the cement industry per employee was over 1,400 tons in Holland, Belgium and the USA, as against about 91 tons in India. The total number of manhours required per ton of cement output in 1957 was 1.50 in the USA, 1.53 in Belgium and 1.75 in Japan. The corresponding average for India was, probably, more than ten times that of the USA.

Although productivity is low in India, it has improved since 1946. This improvement in productivity has been associated with a corresponding increase in the average size of the plant, which enables the industry to take advantage of the economies of large scale production. Increase in the degree of mechanisation is measured by electric power (kWh) consumed per manday, as shown in the table below.

INDEX NUMBERS

1946=100

year	productivity output per manday	mechanisation kWh per manday	installed capacity per plant
1951	165	153	196
1954	253	248	249
1956	225	247	249

The above figures show that productivity (output per manday) was 253 (1946=100) in 1955 and 225 in 1956. This increase in productivity is apparently associated with an increase in the degree of mechanisation, as measured by the consumption of electricity, shown in column 3. A significant degree of correlation was observed by a well known authority in making international comparisons of productivity in the cement industry between productivity

and consumption of electricity per unit of labour. (*Rostas, comparative Productivity in British and American Industry*).

The average size of plant (installed capacity) of the Indian cement industry increased between 1946 and 1956 by 149 percent: from about 71 to 176 thousand tons. The relationship between installed capacity and output per man has been illustrated below for 1957.

Tons of cement

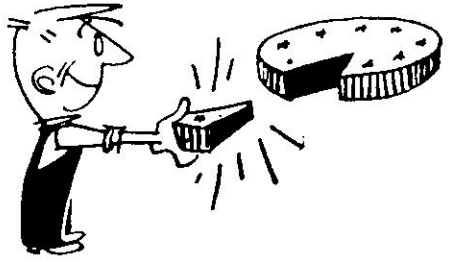
installed capacity in thousand	*output per worker*
below 100	70
100 to 200	161
200 to 300	167
over 300	789

Productivity in the cement industry clearly appears to increase with the average size of plant. It is, therefore, reasonable to presume that the increase in the average size of cement plants in India between 1946 and 1956 must have had a favourable effect on productivity in the cement industry.

The increase in the degree of mechanisation, as shown in the increase in the average installed capacity per plant, points to increased overall capital intensity, which is indicated by the figure of investment per employee and per ton of installed capacity during the period, 1946 to 1956. The index number of fixed assets (net block) per employee (based on figures from the Census of Manufactures) was 467.5 for 1956 as against 100 for 1946, and the corresponding index number of fixed assets (net block) per ton of installed capacity was 184 in 1956 as against 100 for 1946. This means that there is now more capital investment per worker and per ton of installed capacity in the Indian cement industry than in 1946. Even allowing for increase in cost of capital assets due to price rises, there is more physical capital equipment per worker and per ton of installed capacity.

The average investment in gross block per ton of installed capacity in 1957 was Rs 101 in India, Rs 139 in the USA and Rs 88 in the UK, and Rs 20.6 in West Germany. The lower cost in the UK was due mainly to the preponderance of lower-priced old assets; and in West Germany due also to the depreciation of German currency. Although the cost of the gross block is higher in the USA by 40 percent as compared to India, US productivity is higher by about 900 percent.

Sharing the Gains of Productivity !



Productivity of Jute Textiles

GP MUKERJI*

In view of the modernisation programme and the vital role of jute textiles as a foreign exchange earner, it is essential in the public interest to make a special study of the productivity of this industry. The importance that NPC attaches to this study may be judged by the fact that a special productivity group has been set up with the Chairman of NPC itself, as the Chief of the Group. The study printed below is based on the Census of Indian Manufactures whose published statistics are available only upto 1957, but the trend appears to be fairly clear, indicating that the industry needs a productivity overhaul.

ACCORDING TO THE 12TH CENSUS OF Manufactures, the industry provided employment to over a quarter million persons during the last year for which CIM published data are available. The industry had in that year a total productive capital of Rs. 900 million, half of it being fixed capital. It produced goods worth Rs. 1,360 million, of which Rs. 1,150 million were exported. The total value added by manufacture amounted to nearly Rs. 368 million and the wage and salary bills of the industry including the money value of the benefits and privileges extended to labour, was roughly Rs. 288 million.

The industry has a somewhat unusual concentration in the Hooghly Belt of Calcutta. Measured by any economic criterion—employment, investment etc—over 90% of the factories are located in this small strip of land, 60 miles long and 2 miles broad along both the banks of the Hooghly above and below Calcutta. On a countrywide basis, West Bengal alone had in the period under review 101 out of 112 registered factories. The remaining 11 factories were distributed as follows: Andhra (four), UP (three), Bihar (three) and Madhya Pradesh (one). A further characterisation of the non-Bengal mills is that they are of small scale having less than 600 looms each, Bengal having all the bigger and medium size jute mills, as shown below.

Table 1

Size of Jute mills* by looms

Looms installed		*Number of mills*	
		West Bengal	*rest of India*
below	200	4	3
201	400	7	5
401	600	12	3
601	800	12	—
801	1000	13	—
1001	1400	12	—
1401	1800	6	—
above	1800	6	—
		72	11

Thus the jute industry emerges as a major exception to the general rule of small size units in our industrial

* Indian Statistical Institute, Calcutta

* A mill may have more than one establishment or factory (*Source* — Loom Statistics pp. 17,26,27 and 28, IJMA, 1958).

structure. This too is reflected in the employment structure of the jute industry.

Table 2

Employment		*Number of registered factories*
below	50	—
50	99	1
100	249	3
250	499	1
500	999	3
1000	1999	30
2000	4999	50
5000 and above		6

As the table printed above gives figures for 103 factories, the number would also be broadly indicative of the percentage in each category of employment. Over 92% of the factories employ a thousand or more persons per factory on an average working day. The absence of small size units is due probably to the fact that the industry was pioneered by British Managing Agency Houses which conceived industrial organisation on bolder lines. The present study is an analysis of two productivity indices: (a) 'Labour productivity' indices defined as 'production per manhour' and measured by 'value added by manufacture (V) per manhour (MH) or (VMH)' and (b) 'total productivity' or 'operative efficiency ratio' defined as 'the obverse of an estimate of total cost expressed as percentage of the value of products'. Hence it can be taken as a rough measure of the surplus of value of products over material and labour costs. (CP × 100)

Where CP = total cost of production
I = value of total input factors (i.e. the value of fuels and materials used, work done for the factory by other concerns and depreciation of fixed assets).
L = total labour charges paid (wages, salaries and other benefits).
O = gross ex-factory value of output.

The following three tables summarise the statistical results of this study.

Table 3

Labour productivity : V/MH

	West Bengal	Andhra	Uttar Pradesh	Bihar & M.P.	All India
1949	0.49	0.67	0.61	0.58	0.50
1950	0.74	0.74	0.69	0.56	0.74
1951	0.90	1.01	1.29	0.49	0.91
1952	0.73	0.59	0.45	0.45	0.72
1953	0.72	0.62	0.40	0.40	0.71
1954	0.71	0.66	0.47	0.40	0.70
1955	0.60	0.73	0.46	0.54	0.60
1956	0.67	0.68	0.54	0.60	0.66
1957	0.68	0.59	0.59	0.54	0.67

Table 4

Operative efficiency Ratio $\left(\frac{CP}{O} \times 100\right)$

	West Bengal	Andhra	Uttar Pradesh	Bihar & M.P.	All India
1949	98	81	92	89	97
1950	88	83	89	92	88
1951	88	77	73	98	87
1952	91	89	99	99	91
1953	88	87	102	102	89
1954	90	88	95	103	89
1955	95	85	96	95	95
1956	93	88	94	92	93
1957	94	92	93	95	94

Table 5

year	degree of mechaniza-tion*	labour charges per employ-ed person	value added per employ-ed person
1946	267	502	1156
1947	307	695	1109
1948	357	774	1235
1949	449	869	995
1950	553	854	1444
1951	560	902	1856
1952	537	1019	1550
1953	607	1036	1507
1954	667	1060	1520
1955	886	1008	1364
1956	909	1139	1513
1957	1211	1151	1467

* Value of plant and machinery divided by average wage.

The last table shows a clear rising trend in the degree of mechanisation and labour charges. In the value added per employed person, 1951 marks a breaking point, very probably due to Korean war developments. The productivity ratios worked out in the preceding two tables, show ups and downs without any clear increasing trend, though probably a somewhat rising tendency may be incipient, but it is too slow and halting to be quite visible.

The conclusions of this study may be summarised as follows: (i) though highly concentrated, the industry fails to show any correlation between 'productivity indices' and 'regional concentration' (ii) 'unit cost of production' is greater in West Bengal than Andhra (for all the nine years 1949-57) (iii) large size units are not always efficient or economical in terms of 'unit costs'.

The Productivity Race !

Mining Productivity

PG SHETH*

Productivity of the mining industry has been discussed by the author with particular reference to coal mining in India. Along with other mineral industries, coal is undoubtedly the base of the economy. Coal mining has a long tradition in this country but scientific approach and technical progress in this field have been rather slow. Now that modern machinery and safety appliances and techniques are being introduced and both the public and private sectors are being geared to a hundred million ton target, it is essential that we organise this and allied industries to make the most productive use of the extremely large investments being made in the field.

THE OUTPUT OF THE COAL INDUSTRY IS usually measured by output per manshift. The following table gives the trend in the productivity of coal mining since 1961.

OVERALL PRODUCTIVITY OF COAL PER MANSHIFT

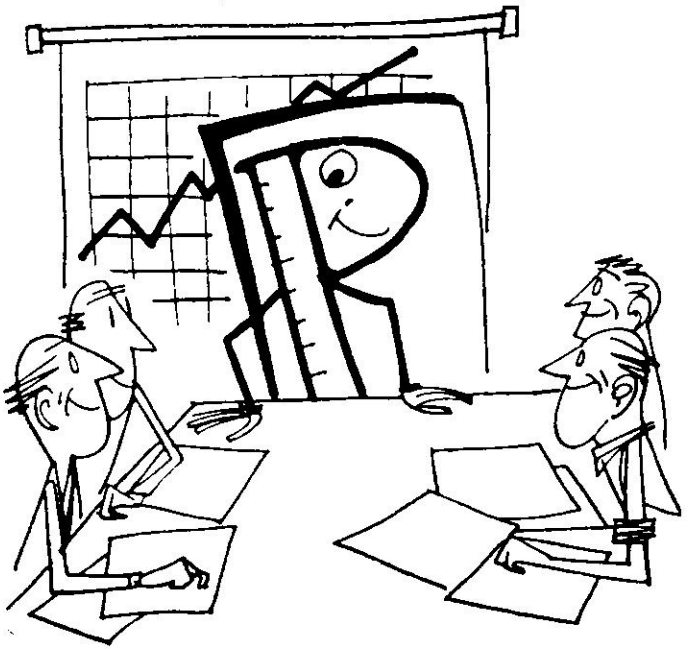
Year	In tons
1951	0·34
1952	0·35
1953	0·35
1954	0·37
1955	0·38
1956	0·39
1957	0·41
1958	0·41
1959	0·42

* Reader in Mining, MBM Engineering College, Jodhpur

Though apparently indicative of continuous improvement in labour productivity, it is really due to the combination of a number of factors: increased investment, management ingenuity, improved conditions of working, higher labour efficiency etc. Output per manshift (OMS) is thus a composite item in which the productivity of labour as such is only one factor. It really cannot be called production efficiency because all the input resources have not been counted and measured. We cannot deduce from the OMS whether real productivity has increased in the sense of a larger output being obtained at lower *per ton* cost of production. The overall cost picture must also take into consideration the other intangible input resources as well as human relations, safety requirements etc. Coal miners, besides being workers are also human beings and citizens. As workers we have to equip them well, protect them adequately and train them in the art of using modern machines. As human beings, they and their families are entitled to minimum health facilities and their children entitled to education as

citizens of a democracy. This may increase costs but it can be said decisively that increased productivity will over a period more than pay for the additional cost involved.

We in this country ought also to follow modern methods of organisation. The foremen of some of the coal mines in the USA are paid bonus on output and cost performance. Bonus to the manager or superintendent for maintenance of safety is also not unknown. What is essential is not that we economise in wages but that we achieve economy in per unit wage cost through proper maintenance of records, adequate work facilities, incentive measures, strict control of operations through time studies, training facilities on the job etc. If all this is done, Indian mining will become a highly productive asset of incalculable benefit to the whole economy.



Labour Productivity in Some Indian Industries

SREELEKHA BASU*

One of the basic indicators of economic development is labour productivity. Increase in the output of a sector depends mainly on the growth of labour productivity. Labour productivity may be measured in terms of the quantity of output produced per unit of time or by the units of time required in producing a unit of output. Hardly any data on the indicators of labour productivity is available in India. Countries with well-developed statistics formulate their economic plans setting up targets of increase in the productivity of labour together with those of output, employment, etc. *So far labour productivity has been a neglected aspect in Indian planning.* The basic reason may be dearth of necessary material on which indicators may be worked out. It is desirable to have some indicators to measure the growth rate of labour productivity in India, in the various sectors, so that correct decisions on the targets of output to be set up, on the increase in income and wage-rates and on the development of the economy may be formulated.

AN ATTEMPT HAS BEEN MADE HERE TO estimate indices of labour productivity in eleven important industries in this country: sugar, vegetable oils, soap, cement, paper and paper board, chemicals, cotton textiles, jute textiles, aluminium, copper, iron and steel, and general and electrical engineering: all covered by the Census of Manufactures. These industries cover some 85 to 90 per cent of the total net value added by the 28 Census Industries. Labour productivity may be measured by physical and/or value indices. But for industries producing more than one type of goods and for the industrial sector as a whole, it is difficult to work out labour productivity in physical terms. On the other hand, the value index of labour productivity constructed on the basis of gross output may be applied to industries producing diverse articles and to industrial sector as a whole. Gross output indicates not only the value of finished goods but also the value of changes in the balances of semi-finished goods and goods in process.

An attempt has been made here to calculate labour productivity with the help of gross outputs in comparable prices. However, the use of gross output at comparable prices may distort the real index of growth, as it does not take into account any alteration in the organisational structure of the industry or of the industrial sector. But only gross output can show the results of the entire labour incorporated in the process of production.

* Central Statistical Organisation, New Delhi

For constructing the value index of labour productivity at comparable prices, we have utilised data on gross output at current prices from CMI reports for the years 1951 and 1958, converting them into a constant price series with the help of the revised series of index number of wholesale prices (base 1952-53=100) for these two years, published by the office of the Economic Adviser, C & I Ministry. Wholesale price indices of all the industries under study are available, with the single exception of "general and electrical engineering". The gross output of this has been converted into comparable figures, for 1951 and 1958, with the help of the wholesale price indices of the group "machinery and equipment". For the group "aluminium, copper, brass etc.", there is no consolidated price index. A weighted average index of *aluminium* and *copper* has been utilised to arrive at the gross value of the group at constant prices for 1951 and 1958. The value index of labour productivity is calculated by the following formula:

$$\frac{Iv.\ c.\ p.}{} = \frac{\frac{\Sigma V_1}{\Sigma T_1}}{\frac{\Sigma V_0}{\Sigma T_0}}$$

Where V_1 and V_0 are the gross outputs at constant prices in the reporting and the base periods and T_1 and T_0 are the number of persons employed in the corresponding periods. The index of labour productivity for the industrial sector as a whole can be worked out with the help of the same formula by taking into account the total value of the gross outputs and the total number of persons employed in the reporting and base periods for all the industries taken together thereby weighting the individual indices to arrive at the aggregate index.

The following table presents the indices of labour productivity for 1958 for the eleven CMI industries and for all the CMI industries taken together.

Indices of labour productivity (1951=100)

	Industries	*On the basis of number employed*	*On the basis of man-hours*
1	Sugar	96	94
2	Vegetable oils	137	131
3	Soap	122	125
4	Cement	121	121
5	Paper and paper board	159	151
6	Chemicals etc	158	162
7	Cotton textiles	88	83
8	Jute textiles	163	135
9	Aluminium, copper, brass etc	167	157
10	Iron and steel	107	119
11	General and electrical engineering	146	159
12	All industries	127	122

These two sets of indices differ due to a number of reasons such as (a) differences in the number of shifts worked in the industries under study (b) the CMI Report gives data on *man hours* worked by labour *directly employed* and not by the whole labour force (c) man-hours spent in maintenance work have also been taken into account (d) further, in the calculation of man-hours no allowance is made for variation in the composition of the labour force on account of age and sex, men, women and children being lumped together. Nevertheless, the broad picture that emerges from the above indices is that notwithstanding considerable variations between the two indices, labour productivity except in sugar and cotton textiles, has recorded a rise—in some cases very considerable—during the period under review, 1951-58.

The following table shows the overall trend from year to year during 1951-58.

Indices of labour productivity (1951=100)

Year	*(on the basis of number employed)*	*(on the basis of man-hours)*
1952	106	105
1953	100	98
1954	113	112
1955	130	128
1956	125	125
1957	125	127
1958	127	122

Breaking the period under review into two halves 1951-55 and 1955-58, both the indices indicate a sharp rising trend to a level 28-29 percent higher than 1951, the first year of the First Plan, except for 1953, when the indices reverted to base level. The labour productivity statistics for the years since 1955 may be taken as indicative either of a broad stability in the level of labour productivity or a slow falling trend.

One more comment: labour productivity index, however constructed, represents a cumulative contribution of a number of inputs: capital, labour, raw materials, technological improvements, organisational efficiency etc. But all these are not always exactly, statistically measurable. Further, at a time, we can only relate the *output* to the *input* of a particular factor of production, to arrive at a concept, which, on the basis of some assumptions, may be called the productivity of that factor of production. We have studied the contribution of labour input only because this is a common measure in all the industries and also because this measure is readily available. It has its limitations, but it has much value for practical purposes. The concept of labour productivity, as adopted above, has a close connection with the question of how far wages can be raised without giving rise to cost inflation. Standard of living of workers is closely related to the growth of labour productivity, and it is in countries with the highest productivity of labour that workers' standards of living are the highest. Workers, in general, share in the benefits of higher productivity, inasmuch as wages rise more or less in step with increase in labour productivity. In under-developed countries, however, where there is abundance of labour but shortage of capital and materials, proper attention should be given to problems of increase in output per unit of capital-cost or material-cost. A study of *output* per unit of capital or raw material would have been interesting, but this has not been attempted here.

WELL-BEHAVED OFFICES

"The head clerk's assistant used to throw papers under his nose without even saying: 'copy this' or 'here is an interesting nice little case' or some agreeable remark of the sort, as is usually done in well-behaved offices...."

Nikolay Gogol

The Construction of A Productivity Index

GC BERI[1]

In an earlier article published in this Journal,[2] the author had argued for a comprehensive attitude to Productivity. His idea is that the concept of productivity should be extended to include input-output labour. In this article he has tried to show with particular reference to the match industry how a total productivity index may be constructed. The match industry has been selected because it has a more or less homogeneous output. The method outlined here can, in the opinion of the author, be used with equal propriety in other industries as well. This way of measuring total productivity is based to some extent on the approach adopted by Reddaway & Smith in their analysis of the Progress in British Manufacturing Industries in the post war period[3].

THE APPROACH TO THE MEASUREMENT OF total productivity, attempted here, is based on an extremely simple formula: net output index divided by a combined input index. Spelt out, the numerator would be the net output in period one, at base year prices, divided by the net output during the base period at base year prices; and the denominator would similarly be the combined inputs during period one, at base year prices, divided by the combined inputs during the base year at the base year prices. The problem would be how to measure the net output and the combined inputs at constant, that is, base year prices. If we can measure the net output of period one at the prices prevailing during the base period, we can arrive at the index of net outputs as given below.

Symbolically

$$\frac{\Sigma\, p_0q_1 - \Sigma\, P_0Q_1}{\Sigma\, p_0q_0 - \Sigma\, P_0Q_0}$$

where p and q are the prices and quantities respectively of the goods produced by an industry; P and Q are the prices and quantities of the inputs used in the industry; subscripts O and 1 denote the base year and the current year respectively; and N is the Net Output Index. Since the Indian Census of Manufactures provides the data relating to the prices and quantities of various commodities manufactured during a year, it seems possible to compile an Index of Net Output of an industry for those years for which the Census data are available.

The compilation of the combined input index is more difficult because some of the inputs used in industry are not subject to quantitative measurement.

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1 Professor of Economics, Vallabh Vidyanagar, Anand

2 The Concept of Productivity, vol 2 number 1 (Oct-Nov 1960)

3 *Economic Journal*, volume LXX number 277, March 1960

If we give up the attempt to measure changes in such inputs, the result would be that the index becomes once again an index of labour productivity, for labour employed or manhours worked would then be the only quantity we can really measure, with this difference that instead of taking gross output we have taken the net output. Accordingly, in this productivity analysis of the match industry the quantity of entrepreneurship input is implicitly assumed to move proportionately to the quantity of capital; hence it is assumed that changes in the entrepreneurship (if any) are one of the factors reflected in the index calculated here.

The labour input index represents the change in manhours worked by labour directly employed. It would have been desirable to work out some equivalent factor for labour done by men, women and children, in order to transform them into uniform manhours. It has of course not been possible to do so in the construction of the index in this article.

The capital index poses a serious problem. The relevant capital concept should be the quantity of real resources —buildings, plants and machinery, vehicles and stocks employed in an industry. As a rule, investment in land, buildings, plant and machinery etc. should be treated separately in order to deflate each one by the specific price index. Due to difficulty in getting appropriate price index for the various types, this approach also has not been adopted here. First, we have classified the capital into two broad categories: (i) working capital and (ii) fixed capital. In working capital, we have particularly taken into account the raw materials, fuels etc used in the manufacture of matches. Here it is possible to have a quantum measurement of various materials used during a period. We can thus construct a Material Input Index for period 1 with base year O by assigning weights to the materials included in the index according to their respective values in the base year. As regards the fixed capital, we have used the depreciation figures which relate to all the fixed assets and which are available in the Census of Manufacture. These figures have been deflated by the Wholesale Price Index for Plant & Machinery. Thus we have obtained the capital input used at period 1 with base year prices. This approach is, however, subject to criticism on the following grounds :

(i) In the Indian Census of Manufactures, depreciation is calculated at the rates allowed by the income-tax authorities for assessing taxable income. Although the rates vary according to the types of assets and industry, they are far from satisfactory so far as an estimate of the actual use of capital is concerned.

(ii) The figures fail to take into account the respective dates when the different assets have been installed in a factory. Since the data of installation of assets cannot be had, it is simply not feasible to calculate the depreciation on any other basis.

(iii) Lastly, the Wholesale Price Index for Plant & Machinery group which has been used for deflating depreciation figures, may not be very appropriate, for this index does not give any indication of the prices of other fixed assets.

Despite the foregoing limitations, we have used this approach for the simple reason that the compilation of a Capital Input Index was considered desirable.

The Weights Used

The next problem is how to assign appropriate weights to the indices of labour and capital and material inputs in order to obtain a Combined Input Index. It is obvious that the weights should reflect the relative importance of the three inputs. The weights have been assigned according to the relative values of inputs used in the base period. In an ideal approach, however, the labour input index will be weighted by the base year wage-bill per unit of labour and the capital input index by the rate of return per unit of capital used. Once again, the reliable data regarding the rate of return per unit of capital are difficult to obtain, and hence this approach was given up.

The Match Industry

On the basis of the approach outlined above, we have constructed a Total Productivity Index for t_1 which is an average of 1955 and 1956 taking the base year as t_0 (average of 1950 and 1951) = 100. The Net Output Index of the industry at t_1 with base year to is as follows:

$$N_{01} = \frac{\Sigma p_0 q_1 - \Sigma P_0 Q_1}{\Sigma p_0 q_0 - \Sigma P_0 Q_1}$$

$$= \frac{78,847,976 - 16,788,605}{64,892,926 - 19,449,726}$$

$$= 136.54$$

The three input indices and the combined input index are as follows:

Input	Weights	Index at t_0 (t_0 = 100)
1. Materials	43.5	86.32
2. Labour	22.9	139.48
3. Capital	33.6	184.82
The Combined Input Index	100.00	131.59

Hence, the Total Productivity Index:

$$\frac{\text{Net Output Index}}{\text{Combined Input Index}} = \frac{136.54}{131.59} = 103.76$$

It is clear from the Total Productivity Index, that the productivity in the Match Industry has increased by 4% approximately at t_1 over t_0.

This finding can be further substantiated with the help of related statistics from the Census of Indian Manufactures as also from elsewhere. This is usually necessary in order to derive additional information about the various aspects of the industry.

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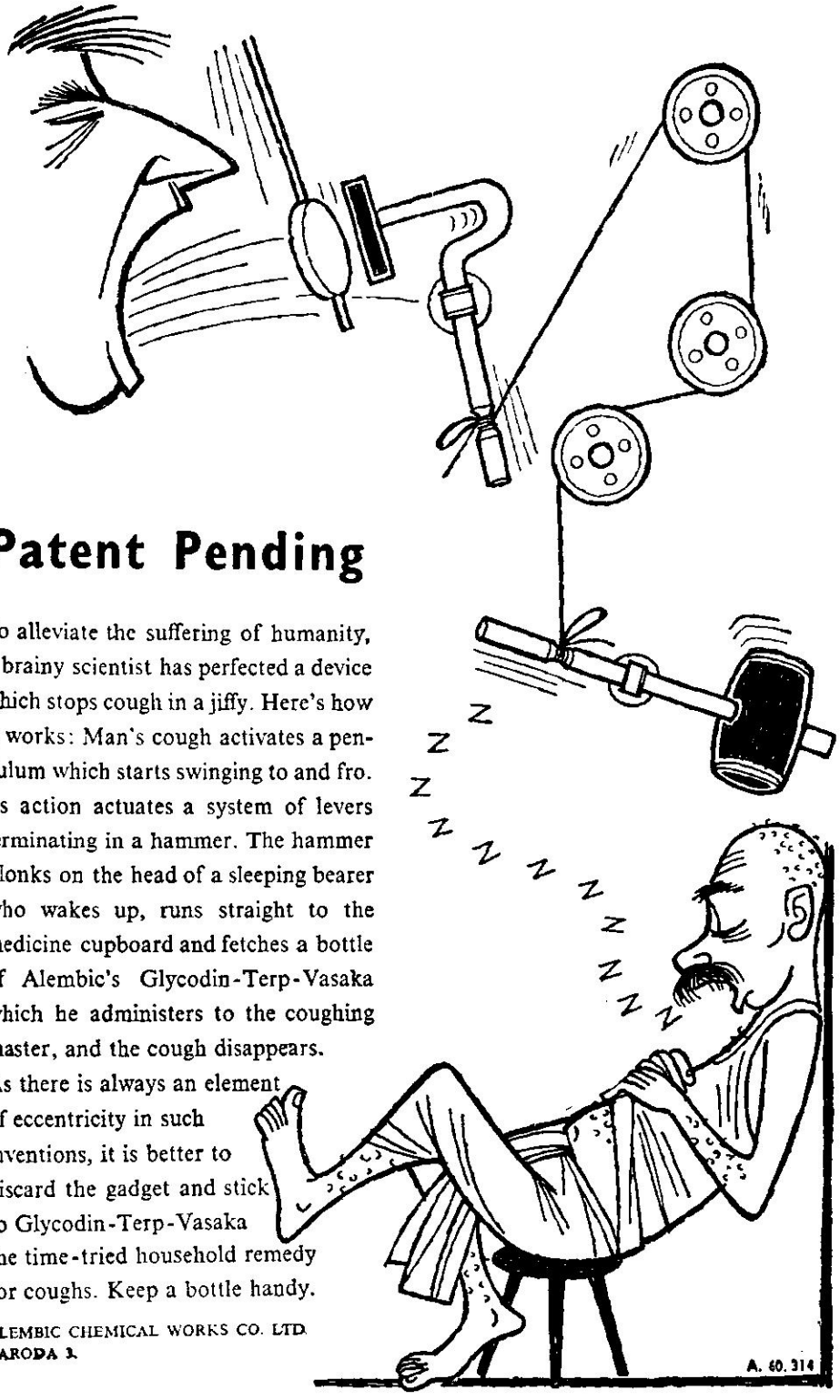

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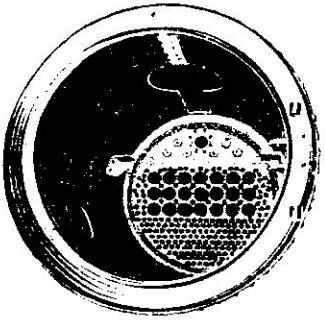

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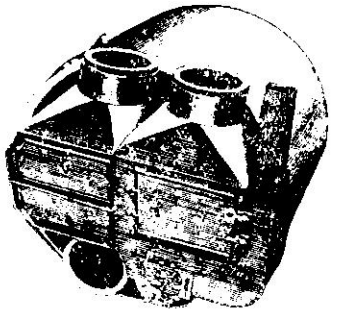

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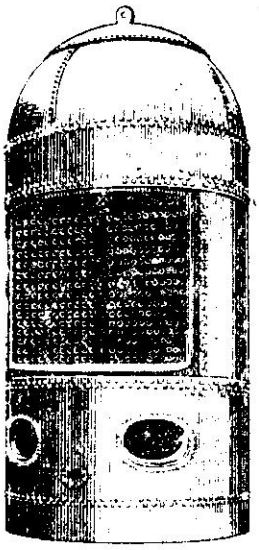

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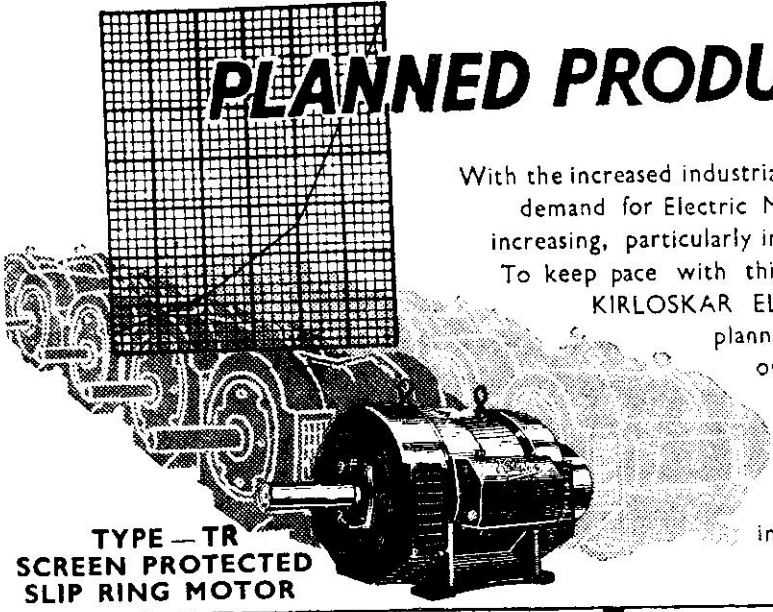

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Interfirm Comparison

HD SHOURIE

The National Productivity Council of which the author of this piece is the Executive Director is interested in the development of the interfirm comparison (IFC) technique in this country, as an effective means for a *continuous upgrading of industrial productivity* for the problem in India is really not so much a dead level of low productivity, as the coexistence of a number of industrial firms with widely varying levels of productivity. It is a common experience to find that industrial establishments, located in the same area and commanding resources of comparable quality, having at one end, a level of productivity comparable to the most advanced countries and at the other end a *level of productivity not worth the mentioning.* In such cases, and these are many, interfirm comparison technique is the easiest way of first creating a consciousness of wholly avoidable productivity differences, which mean so much less money income for those below the line of possibility. As the author has shown, this interfirm comparison technique would be highly profitable even to the best of firms in the competitive world in which we live. For the national economy as a whole, it is a MUST, for it is only a continuous upgrading of productivity through techniques such as IFC that will enable us to earn the foreign exchange we so badly need for development.

INTERFIRM COMPARISON MEANS THE provision to management of figures which will help to show, first of all, how the performance of its firm compares with that of other similar ones, and secondly what the reasons for the differences are. *IFC is not a rival but a supplement to other forms of management control.* It is based on the idea that however satisfactory the performance and progress of a firm may appear from internal records, the only true test of success is that provided by the achievements of other firms.

One striking example quoted by the British centre of IFC was the case of a metal manufacturing company in Birmingham, which had increased its productivity from eight to sixteen lbs. of product per manhour over a period of five years and was very proud of this fact. After taking part in a comparison, it found that other comparable firms had an output per manhour of 30 to 40 lbs.! Another example is that of an electrical firm whose profits on capital employed had increased from 15 to 19%. It found, however, that the average for its section of industry was 25% and that this was being achieved by other firms through greater economy in stock-holding and quicker collection of debts.

The process of IFC

IFC involves bringing together a number of similar firms, getting them to pool their statistics through an organisation they trust. The firms then receive a report showing the comparative performance of each participant and containing data indicating reasons for difference in performance. The statistics may relate to financial and cost mat-

ters or to aspects of physical performance such as output per manhour. Whatever be the area of comparison, the IFC aims not at providing just a mass of statistical data, but at answering specific business questions. It recommends that comparisons should start with data of primary concern to top management—such as profit on capital employed.

The best firm: A well managed firm may be sceptical about the utility of its joining an interfirm comparison. It may feel that it is not worthwhile to do so. But we should not forget the fact that *no one firm is best at everything.* It usually turns out that all those taking part in comparison could improve in some respect, even the *best firms;* and its continued participation in IFC is of vital importance for the preservation of its superiority. It has been reported by the British Centre of IFC that a certain firm which dropped out of a comparison just because it seemed so far ahead, found on resuming its participation a year later that it had dropped behind several other firms in the industry.

The small firm: To the smaller firm IFC is particularly useful. Such a firm is often without the resources to employ specialists in particular management fields, or to afford management consultants. To such firms IFC is a form of self consultancy and diagnosis.

Confidential reports: The firms' figures are processed under conditions of secrecy; their data are not identifiable in the comparative report appearing in the form of ratios and percentages only, with no information to indicate to whom they might refer.

The technique of inter-firm comparison adopted in the USA, UK and other European countries, is one of great potential value to India. The IFC activities abroad have raised the efficiency of whole industries, thereby strengthening their competitive position in export markets: another reason to encourage a technique which might do the same for Indian industries. The importance of interfirm comparison as a tool for management efficiency and productivity can never be over-emphasised. It is also necessary that such interfirm comparison should be undertaken by trade associations.

The system of interfirm comparison establishes independent check on the efficiency of production administration and selling and distribution activities of an enterprise. The benefits of such comparisons have been appreciated by the management in USA, UK and the West European countries. Once the system is introduced in India its efficiency will be readily appreciated by the participants. It would enable them to make an objective assessment of their own results in physical as well as monetary terms. They would be convinced that the method of interfirm comparison constitutes a useful tool in guiding their policies, in weeding out inefficiency in their manufacturing organisation and in improving productivity of the available resources.

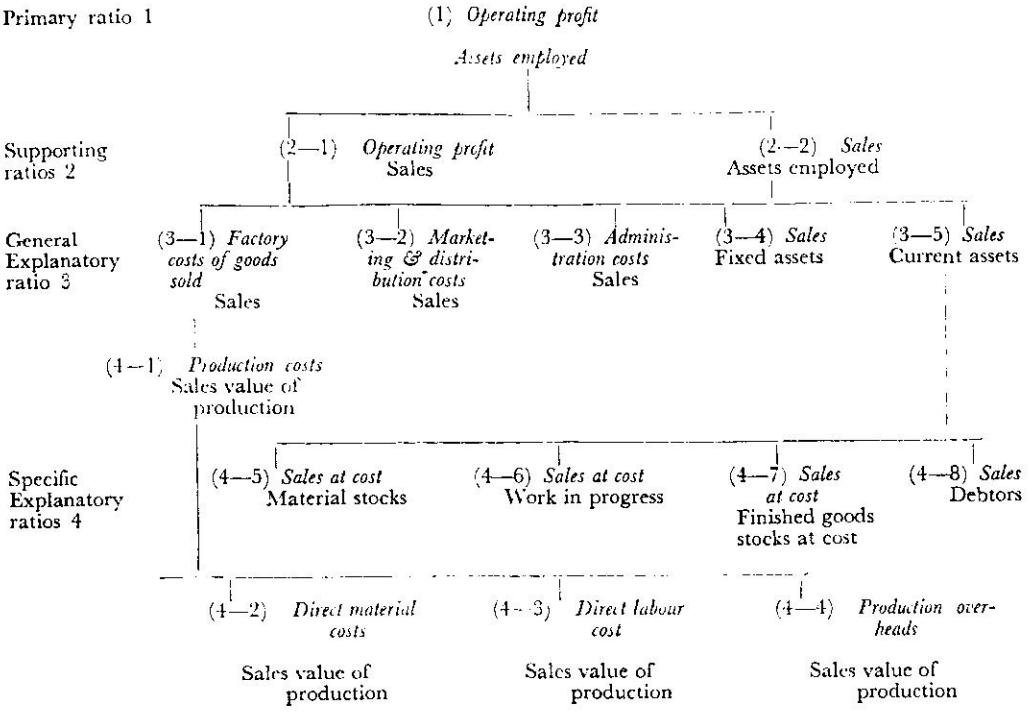
A progressive businessman will spare no pains to obtain such information which is important for many reasons. Such information will be all the more valuable if it enables him to compare his own position with that of other firms in the same line of business. This can be done by a number of firms voluntarily submitting their accounts to an agency in which they have confidence, which will break up their costs into the various components according to a uniform procedure and publish the results without disclosing the identity of the individual firms. If a manager, on studying such a report finds that his material cost or his labour cost or some other elements in his cost are abnormally high and if there is no obvious reason

why this should be so, this will be a strong indication to where we should look for possible cost savings.

Preliminary step : As a preliminary to interfirm comparison financial ratios should be compared. Data for the same are obtained from published balance sheets which are easily accessible. Some important financial ratios for five cement companies of India have been worked out illustratively and printed as an appendix to this article. These ratios can indicate where detailed investigation is warranted and finer cost ratios to be gone into.

Pyramid structure of ratios

It is the object of IFC to help managing directors of participating firms to find out how the overall success of their business compares with that of others and to show them why it differs. In this way the IFC will make participants aware of otherwise unnoticed weaknesses in their policies and operations. It can best achieve this if the ratios compared provide an indication of the overall success of each participant plus a few supplementary ratios carefully selected to help answer the question—stage by stage and in increasing detail—why the overall success of the business does not compare favourably with that of others. Herbert Ingham, Director of the British Centre of Interfirm Comparison, has developed what is now well known as the Pyramid diagram of the ratios. Such a diagram for manufacturing industries is given below.



The set of ratios has to be modified o suit the conditions of specific industries or trades. The pyramid pattern has proved to be very useful because it helps to select relevant ratios and to concentrate investigations on those strictly relevant to top management.

APPENDIX

INTERFIRM AND INTRA FIRM COMPARISONS IN CEMENT INDUSTRY
(Financial Ratios)

Year	C1	C2	C3	C4	C5	Remarks
			I: RATIO OF GROSS PROFIT TO INVESTMENT			
1956	0.124	0.125	0.107	0.077	0.063	Gross profit = Profit before providing for taxation and Managing Agents' commission. Investment = Total assets.
1957	0.085	0.121	0.096	0.041	0.052	
1958	0.083	0.056	0.055	0.031	0.031	
1959	0.060	0.060	0.050	0.0001	0.055	
			II: RATIO OF GROSS PROFIT TO SALE			
1956	0.184	0.220	0.279	0.177	0.122	Financial year for C1 and C4 are August to July and April to March respectively. Figures corresponding to '55-'56 entered against '56 and so on.
1957	0.149	0.235	0.225	0.185	0.094	
1958	0.149	0.149	0.112	0.065	0.063	
1959	0.102	0.107	0.118	0.0001	0.093	
1960	0.107	0.138		0.035		
			III: RATIO OF SALES TO INVESTMENT			
1956	0.671	0.069	0.384	0.435	0.517	
1957	0.566	0.516	0.427	0.224	0.553	
1958	0.566	0.373	0.496	0.476	0.497	
1959	0.585	0.469	0.422	0.445	0.591	
1960	0.622	0.690		0.718		
			IV: RATIO OF INVESTMENTS TO NET WORKING CAPITAL			
1956	1.670	1.482		0.419	0.437	
1957	1.379	0.762	2.675	0.530	0.273	
1958	1.319	2.729	2.262	0.429	0.304	
1959	1.221	3.160	0.684	0.504	0.349	
1960	1.167	1.038		0.508		
			V: RATIO OF NET WORTH TO SUBSCRIBED CAPITAL			
1956	1.668	1.430	1.303	1.119	1.420	
1957	1.613	1.290	1.493	1.113	1.277	
1958	1.597	1.239	1.378	1.012	1.266	
1959	1.583	1.248	1.273	1.090	1.259	
1960	1.566	1.275		1.186		

"Don't you know how things are done? You ought first to have handed in a petition to the office; it would have gone to the head clerk of the section, then it would have been handed to the Secretary and the Secretary would have brought it to me...."

Interfirm Comparison in the UK

Interfirm comparisons provide the management of a firm with a few key figures showing how its operating performance and financial results compare with those of other similar firms in the same industry or trade which, like itself, have contributed their figures to a common pool. These comparisons help managers by drawing their attention to areas in the business which ought to be improved if competitive standards of performance are to be achieved; they also suggest the lines which such improvements should take.

It is a feature of interfirm comparisons that they do not add to the burden of the already busy manager—the results of comparisons appear in the form of a few key ratios whose significance is easily grasped.

IN THE UK, CERTAIN COMPARATIVE SURVEYS—fore-runners of interfirm comparisons for management control purposes—were conducted from about 1890 onwards. They were carried out in a number of industries in connection with wage negotiations and price agreements. The actual conduct of these surveys was usually undertaken by professional solicitors and accountants who specialized in this work as honorary secretaries to employers' or trade associations. Because of their professional status, those concerned did not feel free to disclose any information about their work, so that no details about the methods they used are available.

The terms of compulsory arbitration which were introduced in the Munitions of War Act (1914) led to further comparative surveys being made, since the Arbitration Tribunals set up under the Act had to establish some comparative facts in order to enable them to adjudicate. In the early 1920's there was less interest in surveys of this kind, but they were taken up again in various industries in the late 1920's and early 1930's in connection with rationalization schemes (e.g. the Joint Enquiry in the ship building industry). These surveys, in the course of which it was necessary to ascertain production efficiency practices in the industries concerned, incidentally *helped managements of individual firms to become aware of their relative efficiency and to take steps to remedy defects of labour organization, the plant employed and its layout and utilization.* In this respect these surveys were similar to the interfirm comparisons which are primarily undertaken to provide individual firms with information for purposes of management control.

Activities of this kind were intensified during and after the second world war. The growing interest of British organizations and firms in interfirm comparison as a tool of management control was indicated by the size and composition of the British delegation to the first international conference on interfirm comparisons which took place

* British Institute of Management

in Vienna in September 1956.* The delegation—which included managers, accountants, economists, consultants, and representatives of the *BIM*, trade and trade research associations, *DSIR*, the *TUC*, universities and professional organizations—was impressed by the extent to which practical work of this kind had been developed in other European countries; and on its return to this country strongly recommended to the *BIM* that action should be taken to promote a wider appreciation of interfirm comparison as an aid to management.

Case Studies

The best way of showing how interfirm comparisons help management is to give typical examples of how the results can be used by firms. Six examples have been chosen: in each of these the reader is put in the position of the manager who has just received the comparative report and shown what happens. All these examples are based on actual comparisons conducted in the UK and other countries. They deal with comparisons of figures of particular relevance to those responsible for the overall direction of manufacturing businesses. Such comparisons are meant to show the general manager or managing director how his firm's financial success compares with that of other firms in his industry and, should he find that his firm is inferior in this respect, to draw his attention to the particular department or activity of the business which may be responsible.

Mr Brown & Mr Green

Mr Brown, managing director of Brown and Company Ltd., a company which has taken part in an interfirm comparison, receives a report containing its results. A summary tells him that the figures submitted by firms reflect the improvement in business conditions in the industry as compared with the preceding year; amongst the firms taking part in the comparison, the improvement is indicated by a higher average return on capital—from 9.9 to 11.1%—which is associated with a higher profit on sales and a quicker turnover of capital. On the average, cost ratios have also improved. However, the summary draws attention to the considerable "spread" between the results of the participating firms. Where does Brown & Company stand in this list of 20 firms, for which the experts have prepared a set of 9 important management ratios? Why was this particular set of 9 ratios selected? Since the comparison was intended to be of value to top managers, care was taken to choose a set of ratios which would reflect the comparative overall financial and commercial success of those taking part, and which would also enable them to ascertain the main reasons for differences in between their firms: the first ratio, that of profit/capital employed was selected because a comparatively high return on capital is normally an indication that a business is commercially successful and in a strong competitive

* The papers contributed to this conference by 35 leading European experts have been published in a book entitled "Interfirm Comparison—An Incentive to Productivity" published by the European Productivity Agency of the Organization for European Economic Cooperation (OEEC) Paris.

position*! *Such a business can remunerate its shareholders and employees well and thus attract new capital, as well as operatives and staff of high calibre; it can finance its development with retained earnings and build up reserves.*

A firm's return on capital will be high if the operations in which its capital is employed are profitable and if the capital is used in a way which makes it possible to finance a large volume of sales. The latter will depend on whether a sufficient part of the company's capital is available for current financing (in other words, not invested in fixed assets) and whether the capital which is temporarily locked up in stocks, workinprogress and debtors can be released quickly so as to become available again for further profitable operations.

If a firm finds that its return on capital is lower than that of other similar businesses it will have to probe in two different directions, asking itself:

1. Have our operations been as profitable as those of others? 2. Have others succeeded in obtaining a higher volume of sales from their capital? (Or to use a more popular expression: have they succeeded in turning their capital over more frequently?)

If in fact others operated more profitably, their ratio of profit to sales would be higher. Should a firm find that its competitors showed a more favourable ratio of profit to sales it could broadly establish why this was by comparing its cost ratios with those of the other firms. This comparison would indicate in what fields of activity—production, sales or administration, the firm had operated less efficiently than others.

The 9 ratios used in this set were selected with a definite plan in mind:

1 to make it possible for each firm taking part to compare a primary indication of the economic success of the business

2 to present supplementary ratios which would help the top management of a firm with a comparatively low ratio of return on capital to narrow down systematically the possible reasons for this

The idea behind the ratio being clear, Mr Brown has now to in his company's figures into the blank columns of the table sent to him and is ready for the interfirm comparison. What a shock he is going to get! This year his company's return on capital is well below average; last year's figure compared less unfavourably with the average of the industry. The shock will be all the more severe because Mr Brown was proud to have increased his return on capital from 8 to 8.6% between the two years. He now finds that the *average firm* in the group has increased this from 9.9 to 11.1%.

But need Mr Brown take this too seriously? May be his own figure has been calculated on a different accounting basis, or perhaps the other firms are so different in size or sell such different products that the comparison is not a fair one. These points were seriously considered by the organization that conducted the comparison before it started collecting the figures. It sent to all participants a set of instructions, definitions of terms and report forms which helped them to calculate and return their figures on a uniform basis. In fact, the industry figures represent those of firms of similar size and making similar products. Each firm was asked to give information on its size and product range in the completed report form, thus enabling the organisa-

* There are of course periods during which a firm's financial resources have to be spent on technical, commercial or organizational developments that cannot be expected to yield commensurate returns in the short term. A firm passing through such a development period would obviously allow for this fact in interpreting differences between its return on capital and that of others in its industry or trade.

tion conducting the comparison to group the figures accordingly.

Mr Brown therefore feels that rather than *take refuge behind the excuse of non-comparability* he should regard the difference between his return on capital and that of the others as a danger signal. Accordingly he turns to the supplementary ratios for an explanation of this difference. He finds that the turnover of capital of Brown and Co Ltd, though it improved when compared with last year, is well below average this year; on the other hand, this year's profit on sales is above average (a fact which is substantiated by comparatively good results in the cost percentages). Nevertheless the turnover of capital in Brown & Company is much slower than that of the others. Although the company has a smaller proportion of its capital locked up in fixed assets than the average (ratio 7) his turnover of debtors and stocks is rather too slow. This discovery is the basis for management decisions, designed to eliminate these weaknesses. Mr Brown is determined to make a much better show in the next interfirm comparison.

Mr Green, managing director of Green & Co Ltd also took part in the interfirm comparison in which Brown & Company participated. Mr Green finds that his firm's return on capital this year is comparatively low, although it has risen from 7.6 to 8.4% since last year. But unlike Mr Brown, Mr Green discovers that his turnover of capital compares well with that of others whilst his profit on sales is well below average. This is accounted for by the fact that his production cost ratio is higher than that of the other firms.

What have Mr Brown and Mr Green learnt from all this? They have found that it is dangerous to rely exclusively on comparisons over time between one's own figures; though they may appear to indicate satisfactory progress, they have to be compared with ratios of other firms before the competitive position of the business can be adequately judged. The interfirm comparison has helped the two managing directors to narrow down the causes of weakness in their firms' performance and thus to concentrate on appropriate plans of improvement.

Monsieur Dubois' Iron Foundry

Monsieur Dubois, the managing director of a small iron foundry in Europe which has taken part in a cost comparison, receives a report containing a number of comparative tables. The summary of the report draws his attention to a table, which refers to the melting department and shows a breakdown of the cost of production per 100 kg of molten iron in each of the 7 foundries taking part. From this M. Dubois sees that his firm's results compare unfavourably with those of others. The cost to his firm of producing 100 kg of molten iron is Fr 11.30 as compared with Fr 8.85 for firm I (the lowest cost firm) and Fr 9.35 for the average. M. Dubois knows that these figures are produced on a uniform basis and are therefore comparable. A uniform accounting and costing system was used by the organization conducting the comparison. Examination of the detailed cost breakdown points to a major reason for the difference in melting cost. In M. Dubois' firm the cost of material (iron ore scrap and other ingredients in the cupola charge) is considerably greater than in others, amounting to Fr 7.77 as compared with the lowest figure of Fr 5.39 for firm 2.

M. Dubois knows how to account for some of this difference: his figure of Fr 7.77 includes the cost of incoming transport which other firms returned separately under another heading and which

amounted in other firms to about Fr 5.5 on the average. Furthermore he knows that his products require a fairly high quality of iron so that the iron ore component of his cupola charge, and the price of the grade of iron ore which he uses might be higher than that of the others. However, M. Dubois feels that even when these considerations are taken into account, the difference between the cost of his materials and that of the other firms is not satisfactorily explained, and he therefore decides to look at his firm's purchasing policy and practices, more closely.

Jones of Light Electricals

Mr Jones, production manager of Black and Company, a firm of electrical manufacturers (referred to by the interfirm consultants by the code name of plant C) receives the report on the productivity comparison in which his firm took part. In this case the number of participants is small, and they all make the same kind of domestic table iron. Mr Jones turns to a summary table in the report which gives a general indication of each firm's labour productivity in terms of the direct manhours required per unit of output and per operation. Comparing the figures of his own plant with those of the others, Mr Jones sees that the total direct manhours required by Black and Co to produce 100 domestic irons is higher than that of each of the other three firms, and that this is mainly accounted for by the use of more manhours in the machining, plating, polishing and assembly operations. He accepts these findings because he knows that the organization conducting the comparison took considerable trouble to make sure that the figures would be comparable. Agreement was obtained on definitions of terms (such as *direct* and *indirect* manhours) and also on breaking off points for each operation that is, which processes should be included in such operations as machining, metal forming and assembly.

What caused the difference in labour productivity between Mr Jones' plant and the others? Mr Jones can establish this by reference to the report, which contains further details of manhour requirements in specific operations as well as of the technical features of the firms taking part (e.g. plant, production method, organization). It also contains comments designed to bring out more clearly the reasons for differences in performance between firms. For instance, the report comments as follows on the possible reasons for the less favourable performance of Black & Co.:

"The bulk of the labour time required for machining in plant C is devoted to the manufacture of small parts such as sleeves, spacers, pins and a few parts not used extensively in the design of irons by other producers . . . Total polishing and plating labour requirements of plant C are greater than the requirements for these operations by plants A and B, firstly because plant C requires 9 manhours to buff shells contrasted with 3.4 and 6.1 manhours required by plants A and B respectively, and secondly because plant C uses 8.7 manhours for plating and polishing small parts contrasted with 1.6 manhours in plant A and 3.2 manhours in plant B. . .In plant C, additional polishing requiring 3.7 manhours is performed on the 4 plastic parts of the handle and terminal box. The handle and terminal box of plant A's irons are composed of a single plastic moulding which does not require polishing. Plant B uses a purchased wooden handle."

It appears therefore that the higher manhours required by Black & Co are mainly due to the design of their iron, which seems to consist of a larger number of parts (each requiring machining, plating and polishing) than those of other plants. This suggests to Mr Jones that he should reconsider the design of his product from the point of view of ease of manufacture.

OK Iron Foundries

Messrs OK Iron Founders have taken part in a productivity comparison and have received a detailed report. What does Mr Robinson, the production manager, find when he looks at it? The summary of the report points out that the difference in productivity between the *best* and the *worst* firms taking part in the comparison is of the order of three to one. It draws his attention to a table showing the total manhours required in each firm per ton of good castings. In this table the 13 firms which took part are divided into two groups: firms A-E are those making iron stoves, whilst firms F-N are generally foundries. Mr Robinson notices that his firm, whose results appear under the code letter N, seems to compare very unfavourably with the others; in fact its over-all productivity seems to be the lowest of those in the group most similar to his own (the general foundries) and also the lowest of all the 13 firms which took part in the comparison.

Mr Robinson is interested to see from the separate weekly figures that there were wide fluctuations in the productivity of certain plants (L, M, G and his own) during the five-week period of the comparison. He reads in the report that

"the reason for this is that from one week to another the labour force is constant in these plants, whereas there are considerable fluctuations in the output part of the productivity ratio. These variations could, of course, arise independently of the efficient or inefficient use of resources and could be caused simply by variations in the types of products. They could also, however, indicate *inefficient adaptation of production resources to variations in the orders received. The question of production planning, therefore, plays a very important role here*: it is interesting to note that precisely the firms which are able to make better planning arrangements (such as the stove makers, firms A-E) have comparatively smaller weekly fluctuations in productivity, and their positions in the productivity ladder are also the most favourable in the group of firms taking part in the enquiry."

Mr Robinson notices, however, that even within the group of non-specialized foundries to which his firm belongs there are three (F, H, I) which apparently plan better since their weekly production variations are very small and their actual productivity is relatively high. The report given to Mr Robinson contains a table (not reproduced here) showing that throughout the group of firms differences in total manhours required seem to be mainly determined by the number of manhours spent in moulding. Mr Robinson therefore decides to investigate how his moulding productivity compares with that of the others. Mr Robinson sees from this that there are only two firms (L & K) requiring more manhours than his own to produce a ton of good castings. As to the remaining firms, there are a number of possible reasons for their lower manhour requirements. First of all, their castings may be less intricate than his; in fact he finds from other information given in the report (not reproduced here) that this applies in the case of firm G. Thus he can leave firm G out of account and concentrate on comparing his figures with those of firms F, H, I and M, which make castings of an intricacy similar to his own. A possible reason for their lower manhours is that they are more highly mechanized in their moulding operations. Mr Robinson can check whether this is so by turning to another table in the report. This shows that in fact firms F, H, I and M are more highly mechanized than firm N, and seems to provide Mr Robinson with the explanation of the latter's lower productivity. As the report itself says:

"... it is *difficult to arrive at a good productivity figure for the whole of the firm if a considerable proportion of moulding is done by hand.* In some firms production does not lend itself to long runs, but even where firms make very diverse output, sand slingers and pneumatic rammers can be used to increase productivity. In addition, attention can be devoted to developing specialisation in handmoulding operations."

Herr Schmidt

Herr Schmidt owns a small draper's shop in West Germany. Members of his trade have for some time discussed different approaches to retail management. In Herr Schmidt's view, the success of a draper's business depends primarily on the quality of its personnel; he therefore employs well qualified salesmen, even though he has to pay them high salaries. He also believes that it is essential to support his salesmen by holding an adequate amount and variety of stock. He tests the effectiveness of this policy by following closely the trend of the ratio of sales per employee which he thinks is a good indication of success in his kind of business.

Others in the trade hold different views on these points, and the trade association concerned decided to organize an interfirm comparison designed to provide member firms with some factual guidance. One hundred and eleven firms, all broadly similar in size and in the quality and price range of their products, took part in the comparison. The resulting figures were tabulated with groups according to the sales per person employed achieved by each firm. Herr Schmidt is gratified to find that the comparative figures confirm the validity of his own policy. The table shows that the firms with the highest sales per person employed were the ones which (like Herr Schmidt's) paid the highest salaries and which took the risk of holding the highest stocks per person employed. The table also shows that *the firms which achieved the highest sales per person employed were not the largest,* but they were the most successful since they

> obtained the greatest increase in sales from one year to the other, had the highest sales per constomer;
> used their floor space most productively;
> achieved the fastest stock turnover;
> had the most satisfactory ratios of labour costs to sales and total shop expenses to sales.

An unusually industrious research group at an English bank decided to find out exactly what had happened to 100,000 paper clips bought by the firm earlier in the year. Here is a rundown on the findings. i) The greatest number, 30,000 were dropped on the floor and swept off by the janitor, ii) 19,143 were used as stakes in card games, iii) 14,163 were twisted out of shape or broken during phone calls; iv) 7,200 were used to avert clothing catastrophies (snapped buttons, broken garter etc), v) 5,434 were used for picking teeth, vi) 5,308 functioned as fingernail cleaners, and vii) 3,169 were used to clean pipe stems. That leaves 15,583 paper clips un-accounted for. The operations research investigators think that probably they may have been used to clip pieces of papers together. (From Newsletter).

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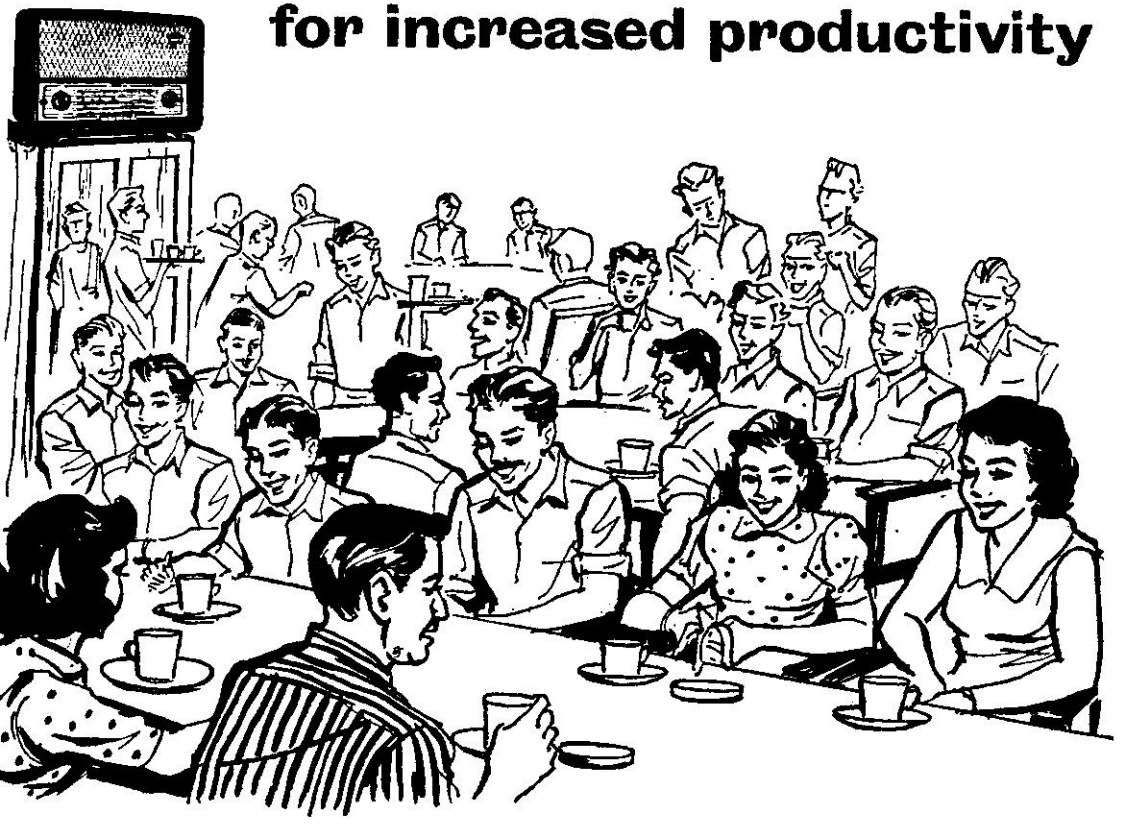

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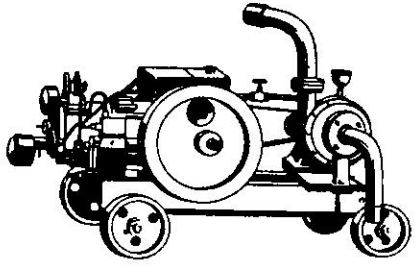

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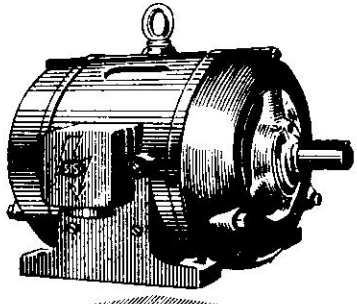

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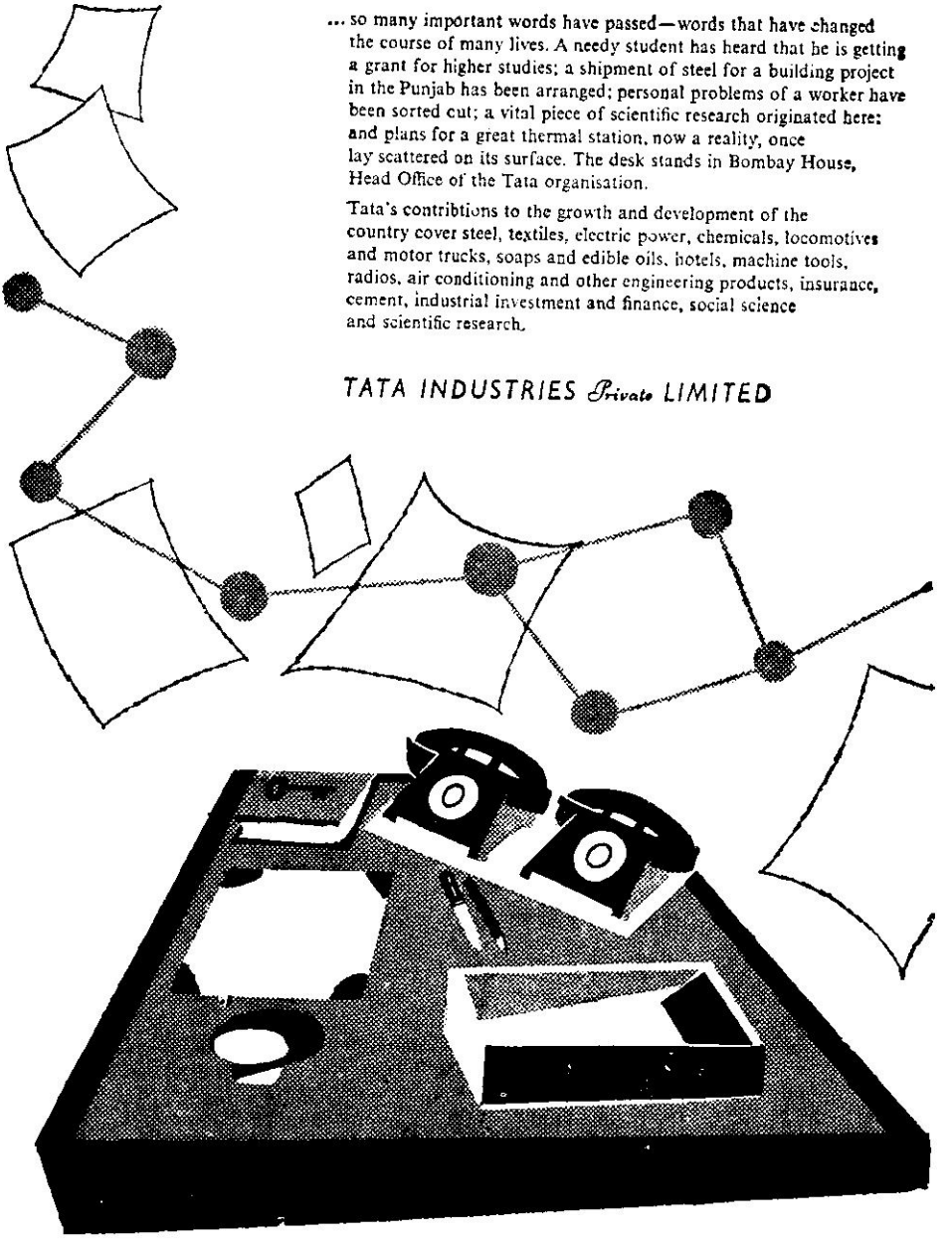

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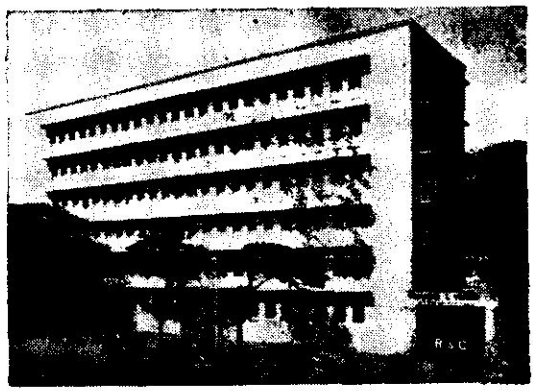

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Measurement of Productivity in State Undertakings and Public Services

GABRIEL ARDANT

The possibilities of increasing productivity in public undertakings of an industrial character, and even in the traditional public services, have been studied in France by the Central Committee of Inquiry into the Cost and Output of the Public Services, a body established by the Government in 1946 and attached directly to the office of the President of the Council. Mr. Gabriel Ardant, the Secretary-General of this Committee, has already published certain theoretical conclusions, notably in his recent work, *Technique de l'Etat—De la productivite du secteur public.* In the following pages Mr. Ardant outlines the methods used—evaluation of the cost and the output of the public services—and gives some of the practical conclusions arrived at by the Committee. Though the examples quoted in the article are naturally taken from French experience, the principles of the method employed would certainly be worthy of consideration in other countries that desire to increase the efficiency of their administrative services and thereby give a fresh impulse to the various activities undertaken by the state.

TO AN OBSERVER OF NATIONALISATION AND other extensions of the functions of the state that have taken place especially since the last war, it might sometimes seem as if there were an idea that all problems can be solved by replacing the head of a private undertaking by a government administrator, creating a new civil service department or expanding an existing one. It cannot be denied, however, that renunciation of the profit motive, the driving force of the system of free enterprise, and the limitation of the field in which an undertaking may be founded by private individuals create serious problems, which those who are scornful of state management have not failed to emphasise. The heart of the problem is whether public management can achieve the same productivity as private management, and whether it is compatible with the preservation of certain kinds of initiative to which the economic progress of the nineteenth century is attributed.

This is a question which can only be answered by studying state machinery, the life of the civil service and its practical working conditions much more closely than is usually done. Looked at from this angle, the problem leads to the question whether certain techniques, and particularly a new method, namely the measurement of results in state-owned undertakings and public services, might not be a necessary if not the only condition for state management if it is to fulfil the aspirations of its protagonists. Briefly, what is needed is a calculation, as exact as possible, of what each state-owned undertaking and public service costs and what it gives in return. It should be possible