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PRODUCTIVITY, the principal organ of the National Productivity Council of India, is a professional, research-based Journal, providing techno-managerial expertise for a productive expansion of the Indian economy. It disseminates knowledge of the latest productivity techniques for pushing forward the growth of Indian industry, and features from time to time the best available papers dealing with different techniques and facets of productivity, and on all aspects of the national economy.

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Towards an Appropriate Technology Policy in India

N.P. Singh*

Introduction

The fact that the strategy of trying to achieve a high rate of economic growth based on massive technology transfers from industrialised countries to the third world has not enabled the latter to solve its basic problems of large-scale poverty and unemployment is being increasingly appreciated all over the world. Technologies developed in advanced industrialised societies, characterised by a plentiful supply of capital resources, relatively-high labour costs, and usually large markets, are not best suited to developing countries like India, with different conditions in regard to availability of capital, labour, markets, etc. The extent to which technologies imported from advanced countries can be adapted to suit the socio-economic and cultural conditions of the under-developed or developing countries is also limited and adaptation itself may be expensive The application of the concept of 'intermediate' or 'appropriate' technology propounded by Dr. E.F. Schumacher to suit the special conditions obtaining in the less-developed countries (LDCs) acquires special importance in this context. The development of appropriate technologies—relatively low cost, employment-oriented, and at the same time reasonably efficient—based on local needs and conditions within the country can offer hopes for the fuller employment of India's predominantly unskilled, unemployed or under-employed labour force, both in the rural as well as urban areas. It also offers a new challenge to India's scientists, technologists and technicians, who form the third largest pool of scientific and technical manpower in the world.

Technologies to Generate Substantial Employment and Fulfill Basic Needs

India's Constitution enshrines the Directive Principles of State Policy

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which, *inte ralia*, require that[1] the State shall, in particular, direct its policy towards securing that......the ownership and control of the material resources of the community are so distributed as best to subserve the common good; that the operation of the economic system does not result in the concentration of wealth and means of production to the common detriment, etc. These principles also envisage that[2] the State shall endeavour to secure, by suitable legislation or economic organisation or in any other way, to *all* workers, agricultural, industrial or otherwise, *work*, a living wage, conditions of work ensuring a decent standard of life and full enjoyment of leisure and social and cultural opportunities and, in particular, the State shall endeavour to promote *cottage industries* on an individual or co-operative basis in rural areas. Among other things, the Directive principles also enjoin upon the State[3] to raise the level of nutrition and the standard of living of its people, and take steps to improve the public health, etc. and also to endeavour to organise agriculture and animal husbandry on modern and scientific lines, etc. The Technology Policy in India, like the Economic Policy, ought, therefore, to subserve the above and other related Directive Principles of State Policy. It follows that this policy must, in particular, aim at the fulfilment of the basic needs of the country's population through providing those living below the poverty line with the means to raise their income levels. In other words, the country should aim at the adoption of technologies which seek to maximise employment in the context of a basic needs strategy.

Definition and Criteria for Appropriateness

Before we proceed further, a discussion with regard to the precise meaning of the phrase 'intermediate' or 'appropriate' technology would be in order. The words 'intermediate technology' have generally been used to signify those technologies which are 'intermediate' in at least three senses of the term: first, such technologies lie in between the traditional forms of know-how and the ultra-modern; second, these are neither very low-cost nor very high-cost; and third, these are neither the most labour-intensive (so as to completely exclude machinery) nor too capital-intensive (so as to reduce the labour requirements almost to zero). The term 'appropriate technology', on the other hand, has

1, 2 and 3 See Articles 39 (b) & (c), 47 & 48 of the Constitution of India been used to indicate the suitability of a technology to a given socio-economic and cultural environment or, in economic parlance, to express the conformity of the technology to the 'factor endowment' of the economy. In most of the developing economies characterised by a comparative shortage of capital and abundance of labour, technologies which are 'appropriate' usually also tend to be 'intermediate' in nature and, in actual practice, these two terms are used as being more or less synonymous with each other. The phrases 'appropriate' and 'intermediate' are thus used in the rest of this paper to mean one and the same thing.

While the concept of appropriate technology is recognised as being of significance to India, there still does not seem to be any general consensus about the exact criteria to be adopted for determining the appropriateness or otherwise of a technology in relation to this country. As discussed, these criteria would depend not only on the socio-economic, cultural and environmental conditions in the country, but also on the value judgements of the society (as determined by its national policy-makers) at any given point of time. Keeping these aspects in view, it is considered that a technology, in order to be classified as "appropriate" in the present Indian conditions, should satisfy as many of the following criteria as possible :

(a) It should aim at providing, or facilitate in providing, one or more of the basic necessities of mankind, such as food, drinking water, clothing, shelter, health/medical care and the like at a cost which can be within the reach of the common man;

(b) It should seek to minimise the use of capital per unit of output or, conversely, aim at maximising production from a given unit of investment;

(c) It should also seek to maximise employment per unit of investment;[4]

(d) It should aim at making the maximum use of local raw materials and other resources available in the country, region or village, specially of the *renewable* ones;

4. See, however, Frances Stewart & Paul Streeten on "Conflict between Output and Employment Objectives In Developing Countries," In Oxford Economic Papers, Vol. 23, No. 2, July, 1971 (pp. 145-168).

(e) It should optimise energy consumption;

(f) It should be simple to operate and maintain, small scale and economically viable; and

(g) It should minimise pollution of the environment and help in maintaining ecological balance in nature.

The above criteria should not, however, be applied rigidly for branding as "inappropriate" capital-intensive technologies required for certain important fields like (i) export promotion, (ii) infra-structural development such as construction of irrigation or power projects and similar works, or (iii) those connected with the security or defence of the country. The setting up of capital-intensive projects or industries may also be required in other areas such as the alleviation of human suffering and illness or in places where working conditions are hazardous or unduly arduous, etc.

It should, perhaps, also be clarified that the idea of "appropriateness" ought not to be utilised indiscriminately to import outdated or obsolete technologies into a country without strict examination of their relevance to the national economy in the prevailing context or, alternatively, to brand any country, region or community as technologically "backward" merely because it deliberately opts for intermediate technology appropriate to its conditions in preference to the modern, labour-sacrificing forms of know-how. In this connection, it would be well to remember that 'modern' need not necessarily be 'capital-intensive' nor 'capital-intensive' good for every kind of economic situation.

Quantification of the Concept

An interesting aspect of the criteria with regard to appropriate technology is whether any of these can be quantified. The qualitative definitions or criteria appear to be too much vague to many people and pose a problem to the planners and the administrators at all levels when faced with an actual choice. It is obvious that the decision of an individual entrepreneur regarding the choice of a technology from within certain specified alternatives is based on a consideration of their comparative economic returns, which can be easily quantified. On the other hand, the State which seeks to promote the use of appropriate technologies has its focus on the social returns or social benefits from a given technology. These returns may take the shape of increased employment provided by the choice of a particular technology or the maximisation of the value of the current output or an increase in the total volume of investible resources available to the economy, etc. The problem thus really is one of striking an optimum balance between private cost-accounting and social cost-accounting. If the social benefits can also be quantified and made comparable at least in some measure to the economic benefits, the problems of decision-making with regard to the choice of appropriate technologies can be considerably simplified.

In attempting to quantify the concept of appropriateness, it must be recalled that most of the developing countries (including India) are faced with the problem of comparative shortage of capital and abundance of labour, resulting in considerable unemployment in these countries. Assuming that the provision of full employment is the goal of the national policy makers in India, an attempt can be made to derive some kind of a quantitative base for determining the "degree" of appropriateness of a technology by comparing its capital-employment ratio with the national "average" value of a similar ratio obtained by dividing the total amount of capital annually available for investment in the country by the average number of jobs required to be created in a year. In the Indian context, this exercise[5] could be done in the manner indicated in the following paragraph.

The Fifth Five-Year Plan of India (1974-79) estimates[6] the increase in the labour force over the plan period as 16.2 million and 8.5 million in respect of the agricultural and non-agricultural sectors respectively. Totalling, we get a figure of 24.7 million or an average addition to the labour force of approximately 5 million per year. The per capita income (in relation to the Net National Income) in India during 1975-76 at 75-76 prices has been estimated to be Rs. 1005 per head[7] and the rate of domestic savings was estimated to be 14.7%[8] of National Income in

5. This exercise essentially follows Graham Jones: The Role of Science and Technology in Developing Countries (pp. 24-26) - Oxford University Press, 1971.

6. See India's Fifth Five-Year Plan (1974-79) Chap. II—The Perspective: Paras 2.43 & 2 45 (pp. 21-22).

7&8. Based on "Quick Estimates" published by the Central Statistical Organisation, Government of India.

that year at the same prices. This gives a total net investment of Rs. 147.74 per head in that year. For an estimated population of 600 million (as on 1-1-1976), the total net investment thus works out to be Rs. 88,644 million. For 5 million new jobs, this gives an average investment of Rs. 17,728.80 per job.

In actual practice, however, the capital cost required to create a work-place in a modern industry in a developed country can be as high as Rs. 500,000. In contrast, an investment of only a few hundred rupees in capital equipment, such as improved hand tools or simple processing machinery, etc. may suffice in India's rural areas to provide gainful employment to an individual or to improve productivity. One thus has a complete spectrum of the intensity of capital investment in relation to its employment potential. Most modern technologies developed under the conditions of advanced industrialised societies tend to be relevant to the upper ranges of the above spectrum, whereas the technologies relevant to the needs of the developing countries are largely those confined to the lower ranges of this spectrum. For economic or strategic reasons, however, part of the investment even in developing countries must go into large, capital-intensive projects, such as irrigation dams, power projects, steel plants, heavy machinery, etc. Each country must thus work out for itself the best "shape" of this investment spectrum to suit its conditions. However, to come anywhere near an answer to the unemployment problem, most new jobs in India must be created at a capital cost well below Rs. 17-18,000 per head. If full employment is the dominant goal, it might well then be argued that technologies whose Capital-Employment ratio exceeds the aforesaid figure are inappropriate for the Indian conditions, subject, however, to certain reservations mentioned earlier.

Sources of Appropriate Technology for Developing Countries

The next question which arises in connection with the application of the concept of appropriate or intermediate technology to developing countries is about the possible sources from which such technologies might be acquired by these countries. As 'appropriate' technology is highly specific to the 'factor endowment' of a country, the best solution obviously would be to generate the needed technologies within the country itself. This can be done in one of the following three ways :

(i) Upgrading of the skills available in the traditional sector of the economy (with a view to improving productivity or quality, but without displacing labour) ;

(ii) Scaling down of the technologies available in the modern, large-scale sector of the economy (with a view to reducing the capital intensity and increasing the labour intensity of the operations per unit of output) ;

(iii) Generating completely new techniques to solve existing problems (specially those faced by the poorer sections of the society), so as to ensure that the new technologies fulfill as many of the criteria of appropriateness for the economy as possible.

It may be observed here that the generation of required intermediate technologies should generally be within the current technological capabilities of most developing countries themselves. It is certainly true of India. However, in certain cases, rediscovery and adaptation of the older techniques or designs of equipment and machinery used in the past by some industrially advanced nations can enable the less-developed countries (LDCs) to generate appropriate technologies suited to their present-day conditions. This apart, a few organisations in some of the developed countries, notably the Intermediate Technology Development Group in the UK and National Center for Appropriate Technology and VITA in the USA as well as most UN agencies, organisations and institutions including the UNIDO, UNEP, ILO and the International Rice Research Institute are also currently engaged in promoting or undertaking the development of appropriate technologies specifically suited to the needs of the developing countries. Hence interested LDCs could also obtain useful information and assistance from the aforesaid bodies or institutions for expediting their march towards appropriate technology.

Development of Appropriate Technology in India

The Appropriate Technology movement in India essentially owes its origin to Mahatma Gandhi, who laid great emphasis on 'Swadeshi' (indigenous) products and the spirit of self-help, specially among the rural people. In the early sixties, the late Dr. E.F. Schumacher, then Economic Adviser to the National Coal Board in the UK, was invited by the Indian Planning Commission to advise her on the rural industrialisation programme. Dr. Schumacher advocated the introduction of intermediate technology as a strategy for raising the earning potential of rural workers in the country. His basic approach was "Find out what the village folk are doing and help them to do it better." In 1966, the Government of India set up the Asoka Mehta Committee to review the progress of the Khadi and Village Industries in the country during the last 15 years. The Committee felt that for a massive programme for the development of rural industries, research facilities would have to be considerably enlarged and properly coordinated in order to supply solutions to the varied technological problems and, even more important, to evolve appropriate technology for small industries in rural areas. For this purpose, the Committee recommended the setting up of a Technological Research Institute for small industries which could conduct research into problems of appropriate technology for rural industries and assist and advise various organisations working in the field of rural industries in the country. Considering the great popular enthusiasm aroused by the concept of appropriate technology and its importance in the national economy, the Union Ministry of Industrial Development in 1969, set up an Inter-ministerial Committee Under the Chairmanship of Mr, K. Balachandran, then Additional Secretary in that ministry, to consider various questions relating to the subject and to find out the necessary steps that could be taken in this regard. The Committee felt that there was need for an organisation in the country which could carry out socio-economic studies, identify technical problems, farm out technological problems to different laboratories and research institutions for their solution, conduct pilot experiments to test the viability of the solutions suggested, produce prototypes of evolved technology and lastly collect and disseminate relevant information and data. The problem was further discussed by the Planning Commission, which in March 1970 recommended that a Cell, instead of a full-fledged institute, for research in appropriate technology be created in the Union Ministry of Industrial Development in the first instance for identifying technical problems and arranging research and investigation with a view to evolving suitable appropriate technology in selected industries. In accordance with the recommendations of the Planning Commission, the Ministry of Industrial Development set up an 'Appropriate Technology Cell' with effect from 1st February 1971 with the following main objectives :

(i) Compiling existing information available on Appropriate Technology;

(ii) Identifying special areas wherein the methodology of appropriate technology would yield greater employment opportunities while at the same time safeguarding the economic viability of the industry;

(iii) Carrying out preliminary cost studies and other economic investigations either by itself or through other research institutions;

(iv) Farming out technological problems to research institutions;

(v) Co-ordinating research projects and commissioning field-testing of prototypes devised by them;

(vi) Negotiating with industry regarding the fabrication of machinery which has been found to be acceptable after field-testing;

(vii) Maintaining close contacts with other institutions interested in the subject, both in India and abroad; and

(viii) Encouraging adoption of the appropriate technological models in selected industries through various publicity media.

The Appropriate Technology Cell began by organising its deliberations with the help of working groups constituted on a sector-wise basis and succeeded in bringing out a number of important reports and publications. Among these, mention could be made of reports in the fields of house building, road construction, small size (vertical shaft kiln) cement plants, bio-gas plants, agricultural implements, etc The activities of this Cell are now being guided by an Informal Advisory Committee, which consists of economists, technologists, administrators and representatives of several organisations engaged in the task of development of appropriate technologies in India.

Both before and after the creation of the Appropriate Technology Cell by the Government of India, a number of institutions and organisations have come into being in the country with the specific objective of undertaking the identification, development and popularisation of appropriate technologies in various fields. Many other institutions having a wider charter for technological development are also turning their attention increasingly in this direction. Mention among these could be made of the Khadi and Village Industries Commission (KVIC), Small Industries

Extension and Training (SIET) Institute, Hyderabad, laboratories under the Council of Scientific and Industrial Research, and the Indian Council of Agricultural Research, National Research Development Corporation (NRDC) of India, Council for Research in Indian Medicines and Homoeopathy, New Delhi, Planning, Research and Action Division (PRAD) of the State Planning Institute, Lucknow, Appropriate Technology Development Association, Lucknow, ASTRA programme of the Indian Institute of Science, Bangalore, Auroville, Pondicherry, etc. As a result of the efforts put in by the aforesaid and other institutions, appropriate technologies in a number of areas specially suited to India's socio-economic and environmental conditions have been and are being developed. However, not only has the total volume of efforts put in so far been quite inadequate, but many of the new technologies have not been accepted by the entrepreneurs, small farmers or landless labourers, etc. (for whom these were intended), for various reasons such as their inadequate profitability, technological imperfection or social unsuitability, etc. Concerted efforts are also lacking for popularising or extending many of these technologies through pilot plants, field trials or demonstrations, where necessary. A co-ordinated picture of the activities of the institutions and organisations working in the field of appropriate technology has also been largely absent, resulting in avoidable dissipation of efforts in certain areas. If we, therefore, wish to utilise appropriate technology as a major instrument for solving India's problems of poverty and unemployment, it would not only require the intensification and proper co-ordination of efforts for the generation of such technologies in various fields but also a clear-cut institutional and policy framework which would facilitate and encourage their utilisation in the country's economic system to an increasing degree. Some specific suggestions for action relevant to the situation obtaining in India (as well as many other developing countries) in this behalf are discussed in the subsequent paragraphs.

Certain Policy Aspects

The starting point for effecting any major changes of economic policy is always a statement of commitment by the concerned national Government to the proposed changes and the enunciation of the new policy in its clearest possible terms. It, therefore, seems necessary that the Governments of developing countries, which intend to use appropriate technology as an instrument for the removal of poverty and unemployment, should state their commitment to the new policy in unmistakable terms. Fortunately, the first step has already been taken in India in this direction Once the new policy has been announced, a major effort will need to be mounted for the identification, development and utilisation of appropriate technologies which aim at the creation of productive employment for the country's unemployed or under-employed labour force, both in the rural as well as urban areas. However, two important points must perhaps be kept in view in this connection :

Firstly, it has been suggested that developing countries having a comparative shortage of capital and abundance of labour should try to evolve technologies which help in the maximisation of production as well as employment for a given investment rather than those that just aim at the maximisation of profits. However, in economies dominated by private enterprise, only those technologies are likely to be ultimately adopted that lead to the maximisation of profits per unit of investment. It would, therefore, be necessary for the concerned Governments to take steps to overcome this apparent conflict of interests. This could be achieved by correcting the 'factcr-price distortions' in the economy, i.e., by the adoption of fiscal policies which would help increase the profitability of the labour–intensive or appropriate techniques above that of the more capital-intensive ones.

Secondly, given the freedom of choice and necessary capital, most entrepreneurs would prefer to deploy costlier machines than employ more workers (i.e., prefer capital-intensive processes to more labour-intensive ones), not only for reasons of profitability (in a distorted factor-price situation) but also because (i) machine management appears to be inherently simpler than men management and (ii) the problems of labour management seem to grow more and more acute with the increase in the number of workers employed under one roof. This tendency would need to be countered, if the utilisation of appropriate technologies is to be genuinely promoted. For this purpose, the Governments will need to re-orient their credit, licensing, wage and labour management policies suitably, so that they not only prefer the establishment of smaller industrial units or units based on appropriate technologies but also keep the demands for premature wage increases effectively under check.

Scope of Application of Appropriate Technology in India

As discussed earlier, appropriate technology in India has not only to be more labour and less capital-intensive, but it has to be oriented towards solving the basic needs of its people living below the poverty line. The concept of appropriate technology in this context need not be kept confined only to the industrial sector, but must be extended to cover agriculture, housing, health and sanitation and, in fact, all other facets of human life-styles and activities. In view of the country's predominantly rural population, the identification of problems concerning the rural areas, specially those of the small and marginal farmers, rural artisans and craftsmen and the landless labourers, and efforts at finding their solutions through the application of science and technology would obviously deserve special attention and support in this connection. An *illustrative* list of the specific fields that could be covered for this purpose in India on a priority basis would include :

(a) Small farm technology;

(b) Agricultural implements and tools;

(c) Water management systems (both for irrigation and drinking purposes);

(d) Low cost, but improved seeds, fertilisers and pesticides for agricultural use;

(e) Post-harvest technology (including grain storage and infestation problems);

(f) Processing of cereals and pulses;

(g) Dehydration and preservation of fruits and vegetables, etc,

(h) Improved animal husbandry, poultry and dairy farming techniques;

(i) Energy systems (including solar energy, wind power and bio-gas plants (both community and family-sizes);

(j) Transportation systems in villages (including bullock-cart improvements);

(k) Low-cost housing techniques and materials;

(l) Improved sanitation systems in villages/towns;

(m) Inexpensive medical and health care (covering 'Ayurvedic', 'Unani', Homoeopathic as well as Allopathic systems). It would seem important to initiate a programme of research in various indigenous systems of medicine along modern scientific lines;

(n) Educational technology for removal of illiteracy and spread of functional literacy, etc. Special emphasis to be laid on the development of needed technical skills and attitude of self-help in the people;

(o) Textile technology (specially covering the problems of 'Khadi', handlooms, and sericulture);

(p) 'Gur', 'Khandsari' and sugar making;

(q) Leather tannery, shoe making, ceramics, pottery, carpentry and problems concerning other rural industries, arts and crafts;

(r) Miscellaneous agro-based and forest-based industries;

(s) Rural engineering workshops for repairs of agricultural machinery, implements, etc.;

(t) Recycling and utilisation of wastes, etc.

It would be relevant to observe here once again that promising work in many of the aforesaid areas has already been completed or is in progress in various Government, quasi-Government and voluntary organisations and institutions in India. Some notable examples are the mini-sugar plant technology, bio-gas plants and improvements in the design of bullock carts, etc.

Modalities of Financing the Programme

In a federal set-up such as in India, the problems concerning appropriate technology are best identified, tackled and solved by the State Governments or their institutions, which are closest to the day-to-day lives of the people and generally possess adequate expertise to do so. With a view to giving a thrust to these activities in the 'state sector', the Central Government could consider launching an adequate number of 'centrally sponsored' schemes (i.e., those funded by the Centre but implemented by the states) in some of the fields enumerated in the foregoing paragraph. Financial assistance could also be rendered to the State Governments for setting up "Research, Development and Extension (R.D.&E) Centres for Appropriate Technology"[9] in selected districts, taluks or villages as a part of the State Science and Technology Plans, with a view to developing economically viable rural industries and creating opportunities for productive employment in the non-agricultural rural sector. Finally, suitable programmes for the development of appropriate technologies may also be undertaken through 'Central sector' schemes by the institutions or agencies under the Central Government directly, specially in fields which are considered to be of nation-wide significance.

Some Suggestions

Apart from specifying the areas where the development of appropriate technologies may be considered to be expedient or undertaking tasks related to the financing and development of such technologies, the Governments of developing countries can do much to *promote the utilisation* of appropriate technologies through the adoption of suitable fiscal, credit, licensing and other policies.[10] Some of the policy considerations relevant to India in this context are discussed below :

(a) Fiscal Policy can play an important role in bringing about a sustained improvement in the employment situation and also in increasing the output of goods of mass-consumption through the use of appropriate technology. The Government should, therefore, examine its fiscal policies in detail and mould them suitably, so as not only to remove the biases towards capital-intensive technologies but also deliberately to favour a pro-labour factor-mix and output-mix. In particular, the possibility of levying differential rates of corporate taxation based on capital-employment ratio for different industries could be examined, so as to favour the deployment of more labour-

9. This would be in accordance with the recommendations made by the Indian Science Congress at its 63rd Annual Session held at Waltair (India) from January 3-7, 1976. The Government of India have recently decided to set up District Industries Centres in all the 460 Districts in the country with similar objects in view.

10. For a detailed discussion of the theoretical considerations relating to this subject, see Frances Stewart: Technology and Under-development (London, Macmillan, 1977) & Nicolas Jecquier: Appropriate Technology—Problems and Promises (Paris, OECD Development Centre, 1976)

intensive technologies. Steps could also be taken to encourage the consumption of the output of labour-intensive industries through various means such as reduction in the rates of excise duties or other indirect taxes on the goods produced by these industries;

(b) Nationalised and Commercial Banks in the country should make credit for setting up small-scale industries and those utilising appropriate technologies (as defined) available on easy and concessional terms. The recent changes in credit policy announced by the Reserve Bank of India with regard to small scale industries (and small and marginal farmers) must, in this context, be considered to be steps in the right direction. However, extension of similar facilities and concessions to other industrial units or persons using appropriate technology also needs to be considered;

(c) The setting up of large-scale or heavy industries in backward areas has not generally helped in solving the problems of poverty or unemployment in those areas. Efforts should be made to encourage the setting up of industries based on appropriate technologies for such areas, specially those which seek to utilise raw materials, skills and labour locally available in these areas. An "Employment Subsidy Scheme" (in place of the "Capial Subsidy Scheme" now in vogue) could be introduced to encourage the industrial development of backward areas;

(d) The setting up of new industries based on technologies which are not considered appropriate to the country's socio-economic and environmental conditions needs to be consciously discouraged through a careful scrutiny of all technologies (whether imported or indigenous) from the viewpoint of their "appropriateness" at the industrial licensing stage. The expansion programmes of the existing industries should also be subjected to a similar test before their approval. A Government department or organisation possessing adequate competence to do so ought to be designated as the nodal agency to render neccessary advice to the Industrial Licensing Authorities in this connection.

(e) One of the common weaknesses of small scale industries is their inadequate marketing ability. Similarly, the sale of products of village and cottage industries and units based on intermediate technologies also poses many difficulties in the face of stiff competition offered by advanced-technology-based items. The overcoming of these problems may require (i) the establishment of suitable organisations to market the products of such industries at 'taluk' or 'district' levels, either under the auspices of the State Government or on a co-operative basis, (ii) grant of purchase or price preferences to such products by Government and quasi—Government bodies, and (iii) reservation of certain products for exclusive manufacture by units in the small scale, village or cottage industries sector. The decision of the Government of India to increase the number of items reserved for exclusive development in the small scale sector is a welcome step in this direction;

(f) Mass publicity media like newspapers, radio and television could be used on a wider scale than in the past to encourage the adoption of appropriate technologies by industries, Care would, however, need to be taken to avoid giving premature publicity to those technologies whose techno-economic feasibility might not have been fully established through adequate pilot plant runs or field trials, etc.

Policy Towards Established Scientific Institutions

It would not be out of place to consider briefly the nature of scientific research pursued by established scientific research institutions in India and the Government policy towards them, with a view to seeing how far these have been effective in the development of appropriate technologies. Here, we may leave out of consideration certain scientific agencies like the Atomic Energy Commission, the Space Commission or the Oil and Natural Gas Commission, etc., as these are necessarily limited in their end-objectives and scope of work by their charters and may, therefore, have little, if anything, to contribute (except in a very limited sense) towards the development of what we describe as "appropriate" technology in this paper. As for the nature of work undertaken by the national laboratories and other research institutions in the country, it could be classified under three broad headings: 'basic research', 'oriented basic research' and applied research'. There has been a general feeling that many, if not most, of the Governmental laboratories have, in the past, preferred 'basic' research to 'applied' research and accordingly devoted more resources and time to the former types of activities than to the latter.

Again, with regard to the 'applied' work, their efforts have mainly been in the nature of 'import substitution' of equipments, products and technologies already developed in the advanced countries *or* in understanding and perfecting the operational know-how of production machinery and equipment to be eventually imported from those countries, so as to avoid the need for entering into 'formal' technical collaborations for the purchase of know-how. Design and development of capital goods or machinery to suit local skills and conditions thus does not seem to have received the attention that it deserves. The result is that both in cases involving 'formal' imports of technology from abroad and in cases where the technology has been 'developed' in the national laboratories or other research institutions themselves, the country has tended to depend, willy-nilly, on the capital goods designed and, therefore, on the know-how developed in the advanced countries. What seems to have been forgotten in this connection is that the development of a local capital goods industry provides the most important basis for appropriate technological innovations, because, to use the words of Hans Singer[11]:

"The machine-producing sector, contrary to widespread belief, is also one of the most labour-intensive of all manufacturing sector. (Further) In addition to being itself labour-intensive, it can affect the labour-intensity of the whole economy........."[11]

It is thus clear that strengthening of design and development skills in India's scientific research institutions with a view to building up strong indigenous capabilities for the manufacture of capital goods suited to local factor-endowments will contribute greatly towards the development of appropriate technology in the country.

Another point of relevance to the work of India's scientific research institutions is that, in the past, few of these have been required to survey or identify the socio-economic problems faced by the country's poorest people living in the urban slums or in the rural and backward areas or to provide low-cost, technologically feasible solutions for such problems. The majority of the said institutions (with, of course, some notable exceptions such as the agricultural and certain medical or other research institutes) have, therefore, remained largely pre-occupied

11. Hans Singer : Technologies and Basic Needs (ILO Publication, 1977), pp. 66-67.

either with basic scientific research or with the development of (essentially western-type) technologies aimed at the production or improvement of goods and services to be consumed by relatively-high income groups rather than with problems involving the community's basic needs. However, thanks to the Governmental efforts to promote the use of science and technology as instruments of social change during recent years and the increasing emphasis being placed in the country on the measures for the welfare of the common man, an ever-increasing amount of scientific research in India is now being gradually directed towards the development of appropriate techniques aimed at fulfilling the basic needs of the people. Government of India's decision to prepare and implement an integrated programme for the development of its rural/backward areas through the application of science and technology and the involvement of its scientific and technological research institutions in this task are, no doubt, steps in the right direction.

A few words about the role of the National Research Development Corporation of India (NRDC), a public sector enterprise of the Central Government involved in promoting the utilisation of the results of indigenous R&D, would also be relevant at this stage. The NRDC not only licenses the know-how developed in India's national laboratories and many other public/private-funded research institutions in the country to the entrepreneurs. but also finances the setting up of pilot plants or proto-type development and demonstration units for new technologies on a cost-sharing basis, generally on very favourable terms. Already, a majority of technologies licensed by this Corporation are those appropriate for small and medium scale operations and over 350 such technologies are now in actual commercial production. Given the needed financial support and appropriate policy directives, the NRDC can thus play an increasingly important role in promoting the development and utilisation of various types of intermediate technologies in industry in the context of a revitalised appropriate technology policy.

A National Centre for Appropriate Technology

Following the suggestion originally made by the Asoka Mehta Committee (mentioned earlier), some discussion has been going on in India as to whether a separate and autonomous institute need to be set up in the country for undertaking research, development and extension work in the field of appropriate technology at the national level. Supporters of this idea argue that in view of the vital promise which a widespread application of appropriate technologies holds in the Indian situation and the fact that the tasks of identification, development and extension of these technologies are too onerous to be efficiently discharged by a small 'Cell' currently located in the Union Department of Industrial Development, it is absolutely necessary to establish a full-fledged autonomous research institute with adequate man-power, financial support and material facilities at the national level in order to achieve desired objectives. Opponents of this proposal, however, point out that in view of the considerable diversity of disciplines covered under the heading of 'appropriate technology', the establishment of a centralised institute to conduct hardware research in all the areas at the same time is not feasible and that this would,at best, lead to an avoidable and expensive duplication of the facilities already available in other Government, quasi-Government or voluntary research institutes and laboratories (such as those referred earlier) in the country. An alternative to the establishment of an independent, autonomous national centre for appropriate technology would be to strengthen the organisational structure and finances of the 'Appropriate Technology Cell' itself. This 'Cell', could perhaps be strengthened by the induction of a few technologists and sociologists as well as by the provision of needed finances and administrative support, so as to enable it to discharge its broad-based and onerous duties in the context of a vigorous Appropriate Technology Policy more efficiently.

Conclusion

The usefulness of appropriate technology as an instrument for improving the income levels of the poorest people and solving the problems of large scale unemployment in developing countries can no longer be disputed. The tasks relating to the identification and development of these technologies in various fields and, more particularly of the promotion of their utilisation in the face of stiff competition offered by modern technology are, however, stupendous and call for a serious consideration of some of the suggestions made herein. □

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tion of these difficulties would determine whether the transfer was successful or not.[3]

This paper concentrates on some of the operational problems of transferring technology from an advanced production system abroad to

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1. Two major international conferences :
   (a) *International Seminar on Technology Transfer*, Dec. 11-13, 1972, CSIR, New Delhi, 1973 (3 volumes)
   (b) NATO Advanced Study Institute on Technology Transfer, Europe, France, June 24 to July 6, 1973. The proceedings were edited by Davidson, H.F., Cetron. M.J., and Goldhar, J.D., *Technology Transfer*, Noordhoff, London, 1974.

   Special Issues of
   (a) *Productivity*, Vol. XVI, No. 2, July/Sept. 1975, New Delhi.
   (b) *R&D Management*, Vol. VI, 1975-76, Oxford.

   In addition, there are numerous United Nations publications devoted to Technology Transfer.
2. Meursinge, J.H., *Practical Experiences in Transfer of Technology*, Technology and Culture, Vol. XII, No. 3, July 1971, p. 470.
3. Hayden, E.W., *Technology Transfer to Eastern Europe*, U.S. *Corporate Experience*, Praeger, New York, 1976, p. 25-27.

a less advanced system in India. It is based on extensive and in-depth interaction with some of the production and design engineers in the host country, India, who tackled and solved these problems. The paper is part of a larger ongoing study covering production, product development and marketing, and looks at the operational problems from the Engineers'/Managers' viewpoint, rather than the traditional academicians'/economists' angle. In addition, other studies cover the transfer of in house technology to production and subsequent marketing, and a CSIR technology to a small scale industry.

Operational Problems

While it may sound paradoxical, the operational problems of technology transter from an advanced to a developing country become more complicated as the recipient country industrialises. When the developing country has a rudimentary industrial base, most of the collaborative agreements are on a turn-key and/or equity participation basis. Under these circumstances, the supplier or donor of technology is entrusted with the task of choosing the type of production equipment to be installed, setting up the plant and bringing it on stream. As their industrial base broadens, the governments of recipient countries encourage a practice of "unbundling", i.e., buying only the know-how or design.[4,5] Thus, when an industrial organisation in a less-advanced country takes licences for a particular product or range of products to be manufactured in existing factories, their engineers and other technical personnel have to tackle the numerous operational problems that crop up during production initiation.

By and large, these problems can be divided into the following categories :

(a) *Machine Tools* : Foreign company uses special-purpose or sophisticated machines while the recipient company has conventional or general-purpose machine tools only or a limited number of special

4. See UNCTAD, *Guidelines for the Study of the Transfer of Technology to Developing Countries*, United Nations, TD/B/AC11/9, New York 1972, p. 9-10, for advantages and disadvantages of "packed" transfers.
5. For example, see the Indian Government's Industrial Policy Statement laid on the table of Parliament on December 23, 1977.

purpose machines. The foreign company, with a view to minimising labour costs, improving quality assurance, etc., has Numerically Controlled (NC) machines on which a component is machined in one or two settings. In contrast, Indian companies, with their conventional machines, may have to machine the same component on three or four different machines, which may require five or six settings.

(b) *Production Tooling* : The foreign collaborator uses expensive tooling like jigs and fixtures, dies, etc., that are economical only for large-scale manufacture of the components. The Indian company manufacturing a relatively small quantity tries to minimise tooling costs by using highly-skilled operators on conventional machines. Further, the jigs and fixtures used by the foreign company may be suitable for the one-setting NC machine, whereas the recipient company may require separate jigs and fixtures for milling, turning, drilling, etc. This means that new production tooling has to be designed to suit the production process adopted for conventional machines.

(c) *Engineering Standards* : Standardisation differences occur when the collaborator uses his national standards and the Indian counterpart uses Indian standards [6,7] A typical example of differences in standards is found while specifying fits and tolerances. Some countries follow the shaft basis to specify fits while in India the hole basis is followed, since we have to depend on standard reamers available in the market. This means that a large number of blue-prints have to be redrawn.

(d) *Raw Materials* : Linked in some way to standards specification are the raw materials used in the components. For example, the foreign company may use an alloy that is freely available in its region but not so readily available in India. Further, when the Indian company tries to indigenise the raw materials, it may have to use an alloy that differs slightly from the one used by the foreign company.

(e) *Import of Selected Components* : In some cases, certain components cannot be manufactured with the existing facilities. Since the scale of manufacture is not very large, it may not be worthwhile purchasing a special-purpose machine In such cases the component has to be

6. Teece, D.J., *The Multinational Corporation and the Resource Cost of International Technology Transfer*, Ballinger, Massachusetts, 1976, p. 22.

7. Meursinge, *op. cit.*

imported, and the inevitable delays taken into account.

(f) *Incorporating Design Changes* : Since the foreign company wishes to maintain its reputation even when transferring the technology, it usually insists that the Indian counterpart should not deviate even fractionally from the design specifications.[8] Fortunately, in the case of most mechanical components many collaborators allow some leeway to standardise, rationalise, etc. Further, the agreement may stipulate that future design changes made by the foreign company must be automatically incorporated into the indigenous products. Invariably, the foreign company does not communicate the reasons why the design modifications have been introduced. This means that the Indian counterpart has to incorporate many of them without really appreciating the reasons for these changes and their appropriateness to local conditions.

Some additional problems of this nature can be attributed to differences in the ambient conditions (temperature, humidity, etc.). One of the primary objectives of the R&D effort in Indian companies is towards adapting imported technology.[9] This is another instance of genuine research efforts not producing anything new but getting lost in the collaborative process.[10]

Operating Lever-Example

Some of the above problems will be illustrated by taking a specific case of a component called the Operating Lever.

This lever consists of 8 separate parts that are welded together and then machined. The foreign company performed all the machining operations on a Numerically Controlled (NC) machine, in one setting and with one jig. The Indian company, however, did not have any NC

8. Subramanian, K.K., *Import of Capital and Technology : A Study of Foreign Collaboration in Indian Industry*, Peoples' Publishing House, New Delhi, 1972, p. 149.

9. Prasad L, *The Objectives of In-house R&D in India—A National Survey*, Journal of Scientific & Industrial Research, Sept. 1978. (Other details awaited)

10. Krishnaswamy, K.N., *et al*, *An Empirical Analysis of R&D Management Practices in a Few Manufacturing Companies*, Department of Industrial Management, Indian Institute of Science, Bangalore, 1974, unpublished report, p. 58.

machines. The component could have been fabricated on a horizontal boring machine, but the capacity at this centre was very limited. Hence, it was decided to use three conventional machines, viz., a lathe, a milling machine and a drilling machine. This resulted in quality control problems since it was very difficult to maintain parallelism and perpendicularity between the various faces, holes and the axis of the component. In some cases, additional grinding helped solve some of the quality problems, but this resulted in duplication of some of the operations, larger cycle terms, etc.

Because of the problems faced in meeting the quality control specifications, the production process had to be revised three times as detailed below :

Process I

The various parts are assembled on a welding fixture and tack-welded. The component is then removed from the fixture, inspected and the welding completed, after which it is heat-treated for stress relieving. The component next goes to the machine shop. There, the component is mounted on a milling fixture and the spacer and brackets faced. It is then mounted on a drill jig and the holes drilled and reamed. Because of the change in setting between the two operations the surfaces and bore axes were usually not perpendicular to each other within the tolerance limits specified in the blue-print.

Process II

The parts of the component are welded together and then sent to the machine shop. After milling the two bracket faces only, the component is loaded on to the turning fixture. The spacer is faced on the lathe and the centre hold drilled and bored. This is done to ensure perpendicularity between the spacer face and central bore. Taking the centre bore as location, the component is mounted on a drill jig and the other holes drilled. This resulted in parallelism problems between the spacer and bracket faces. When grinding operations were performed to maintain parallelality, the perpendicularity between the faces and the bore could not be maintained.

Process III

After welding, the job is loaded on a turning fixture, the spacer faced and the centre hold bored. The component is then clamped in a milling fixture with the centre hold as location and the brackets are milled both inside and outside. The job is then mounted on a drill jig taking the centre hole as location. The other holes are then milled and reamed according to specifications. Since the centre hold is taken as location for the subsequent machining operations, the third process resulted in a component which came up satisfactorily to all the specifications laid down.

Attempts to tailor the production process to the equipment available meant that fresh process charts had to be designed, and every time the production process was modified, new charts had to be prepared. Therefore, it took an inordinately long time for the production to stabilise. Some of the other consequences of adopting the indigenous production process have been :

(i) *Long production cycle times* : This was due to the number of settings required to machine a component, and also the idle time between machining centres.

(ii) *Inventory* : Because of longer production cycle times, the work-in-progress inventory had to be larger. In addition, there was the material handling problem since the component had to be transported from one machine centre to another.

(iii) *Quality Control* : Since a number of machines and operators were involved and the number of settings greater, maintaining parallelality and perpendicularity specifications became a major problem. Consequently, the number of inspections increased, since the component had to be cleared after each stage.

(iv) *Tooling* : Since the component had to be machined on different types of machines, a variety of jigs and fixtures were required. Every time the production process was changed, the tooling also had to be redesigned.

All these increased the cost of production and decreased productivity. Unfortunately, data to compute the costs incurred in adopting the indigenous production process is not available. Even the dates on the revised blue-prints could not be used to determine the time lag before production stabilised, because at least 16 other minor changes have been incorporated into the operating lever design, on the advice of the foreign company.

Discussion

The design and production engineers tackling these and other operational problems have a knowledge of "general technology" and are gradually but painstakingly acquiring expertise in "system-specific and firm-specific" technology.[11] To these engineers, their involvement is partly emotional and any failure, in addition to earning the wrath of management, results in a feeling of inadequacy and a loss of confidence in themselves. They can be helped if " . answers can be obtained by combining ... astute historical insights with recent practical experience".[12]

It is interesting to reveal that when the operating lever example was presented as a case to executives attending the programme on the Management of R&D systems at the ASCI there was near unanimity that inadequate management controls were primarily responsible for the unnecessary delays.[13] However, many participants admitted that faced with a similar situation they could make the same mistakes, especially when the solution appears to be just round the corner.

Published literature on Technology Transfer has often stressed that one of the major factors determining absorption of foreign technology is a pool of skilled engineers and technicians. In this regard, India is very fortunate since it has the third largest stock of scientists, engineers and technicians (next only to USA and USSR), whose competence can be gauged by the demand for their services all over the world. However,

11. Hall, G.R. and Johnson, R.D., "*Transfers of United States Aerospace Technology to Japan*", In .Vernon, R(ed.). The Technology Factor in International Trade, National Bureau of Economic Research, New York, 1970, pp. 308-309.

12. Meursinge, *op. cit.*

13. For similar conclusions, see Rothwell, R., *Some Problems of Technology Transfer into Industry*, IEEE. Trans on Engineering Management, Vol. EM-25, No. 1, Feb. 1978, p. 20. "...with proper management and control, nearly all the failures (of technology transfer)... could have been transformed into successful cases..."

these specialists have rarely been given the opportunity to realise their full potential in India, primarily because of an antithesis of the "NOT INVENTED HERE" syndrome, the decision maker's (industrialist, executive or bureaucrat) partiality for anything that is foreign. Unless our engineers are given a chance to master the core of the imported technology, and provided with sufficient resources and facilities to work on the next generation of technologies, India will continue to depend on foreign expertise and know-how for her industrial development. Now that the Government of India is encouraging outright purchase of technology, the decision makers should be alerted to the potential problems of this new approach. □

Forging Processes

Joseph Stanislao*

In all forging processes metal is heated to a plastic state. It can then be readily formed by pressure or impact into a predetermined shape. Forging processes may be roughly classified as flat die (smith) forging, drop forging, upset forging, press forging, roll forging, and rotary swaging.

Hot-working or forging operations are done at temperatures above the recrystallisation temperature of the metal so that annealing and work hardening cancel each other. For steel the temperature must be above the critical range and the work is usually started at temperatures ranging from 2,200° to 2,500°F. For nonferrous metals the temperatures are much lower, depending on the alloy composition. The plastic temperature range varies widely for different kinds of metals and alloys.

Forming metals to shape by forging is about the same in the various forging processes. All are commercially proven processes capable of changing raw materials, such as bars and billets, to a predetermined shape. The advantages claimed for these processes include :

1. Decreased porosity of metal,
2. Refinement of coarse grains,
3. Generally improved physical properties,
4. The breaking up and uniform distribution of the impurities in the form of inclusions, and
5. Minimum finish allowances necessary.

Smith Forging

Flat die or smith forging consists of hammering the heated metal bet-

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ween flat dies in a steam hammer. It is similar to hand forging as practised by a blacksmith in that no impression dies are used and considerable skill is required to shape the metal. The nature of the process is such that close accuracy is not obtained nor can complicated shapes be made. Forging hammers are made in the single or open frame type for light work and the double housing type for heavier service. The process is used primarily for short-run jobs and repair work which do not warrant the expense of special tooling. Forgings, ranging from a few to over 200,000 lb., are made by flat die forging.

Drop Forging

Drop forgings are produced by shaping the hot plastic metal in closed impression dies. Impact blows of the ram, carrying one of the dies, strike the plastic metal held on the base in the other die, compelling it to conform to some planned shape. Both dies are held in perfect alignment. To insure proper flow of the metal during these intermittent blows, the operation is divided into a number of steps. Each step changes the form in a gradual fashion controlling the flow of the metal until the final shape is attained. The number of steps required varies according to the size and shape of the part, the forging qualities of the metal, and the tolerances required. For products of large or complicated shapes a preliminary shaping operation may be required, using more than one set of dies.

A finished forging will have a thin projection of excess metal extending around it at the parting line. This excess metal is provided to insure complete filling of the dies and is removed in a separate trimming press immediately after the forging operation. Small forgings may be trimmed cold. Care must be taken in the trimming operation not to distort the part. The forging is usually held uniformly by the die in the ram and pushed through the trimming edges. Punching operations may also be done while trimming. Fig. 1 illustrates the total drop forging system.

Upset Forging

Parts produced by the forging machines (upsetters or headers) are made by pressing or squeezing the plastic metal into enclosed dies rather

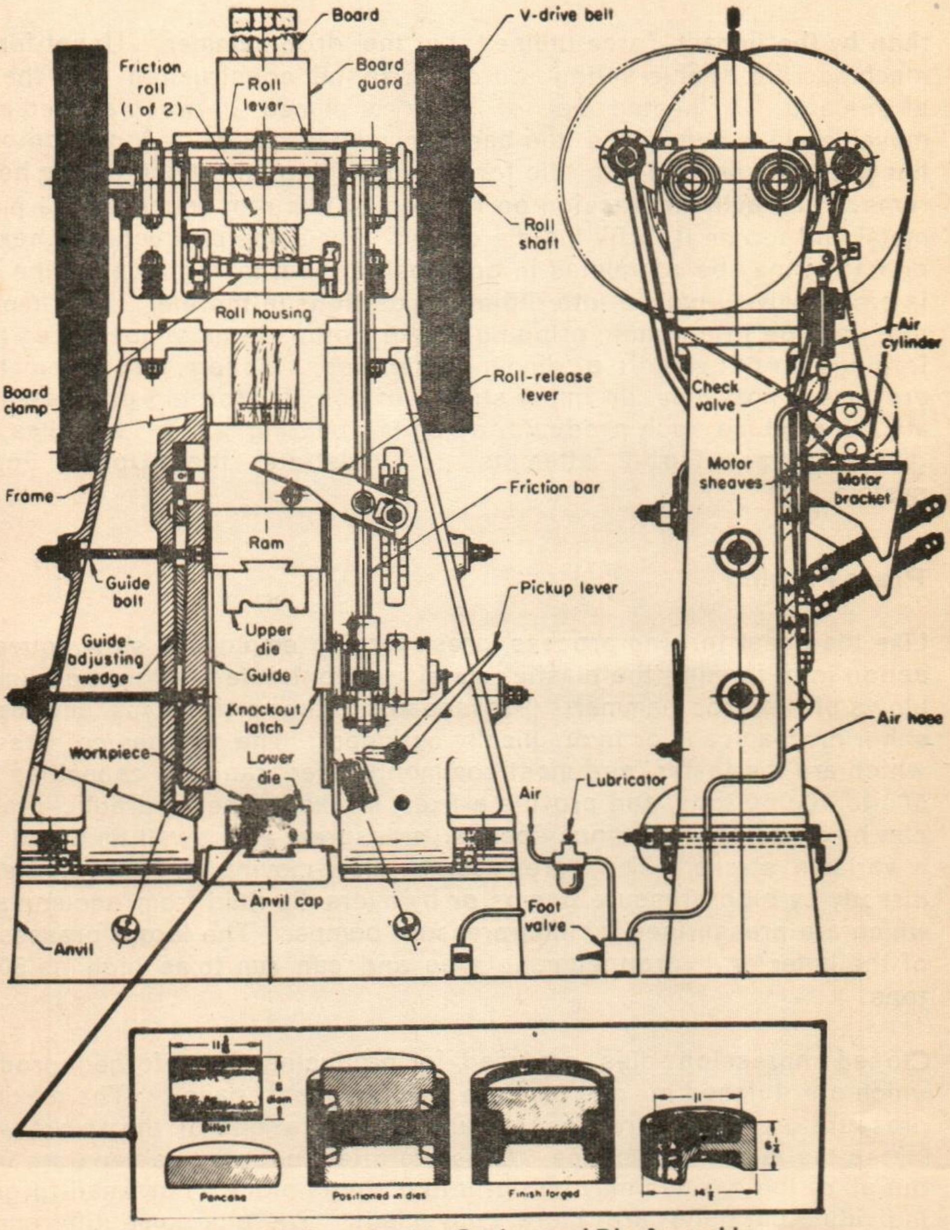

Fig. 1 : Drop Forging System and Die Assembly

than by the impact force utilised by the drop hammer. Upset forging machines are double-acting and of horizontal construction with the dies at one end. A heated bar of stock is placed between a fixed and a movable die which grips the bar firmly when closed. A portion of the bar projects beyond the die for the upsetting operation by the header rams. The cavity impression on the end of this ram squeezes the plastic metal and forces it to fill the die cavity. For some products the heading operation may be completed in one position, but in most cases the work is progressively placed into different positions in the die. The impressions may be in a punch. gripping die, or both. In most instances these forgings do not require a trimming operation. Modern forging machines are used not only in initial stages of complex forging processes, but also to produce such products as bolts, bearing racer, spindles, and gear blanks. Fig. 2 attempts to illustrate the Upset Forging system.

Press Forging

Like the upset forging process, press forging employs a slow squeezing action in deforming the plastic metal as contrasted to the rapid impact blows of the drop hammer. Presses are of the vertical type and may be either mechanically or hydraulically operated. The mechanical presses, which are the faster and most commonly used, range in capacities from 500 to 10,000 tons, and provide a fixed stroke. The hydraulic presses can be adjusted to various speeds, pressures, and dwell time and have a variable stroke. They are usually slow-moving and activated either directly by high-pressure pumps or by hydraulic fluid from accumulators which are pressurised by high-pressure pumps. The larger presses are of the latter or hydropneumatic type and can run to as high as 50,000 tons.

Closed impression dies are used for producing press-forged products which are finished in one to three steps in most cases. The maximum pressure in these presses is built up at the end of the stroke which forces the metal into shape. Dies are often mounted as separate units, but all of the cavities may be put into a single block. For small forgings, individual die units are more convenient. There is some difference in the design of dies for various metals. Forgings of brass and bronze can be made with less draft than steel; consequently, more complicated shapes can be produced. These alloys flow well in the die and are

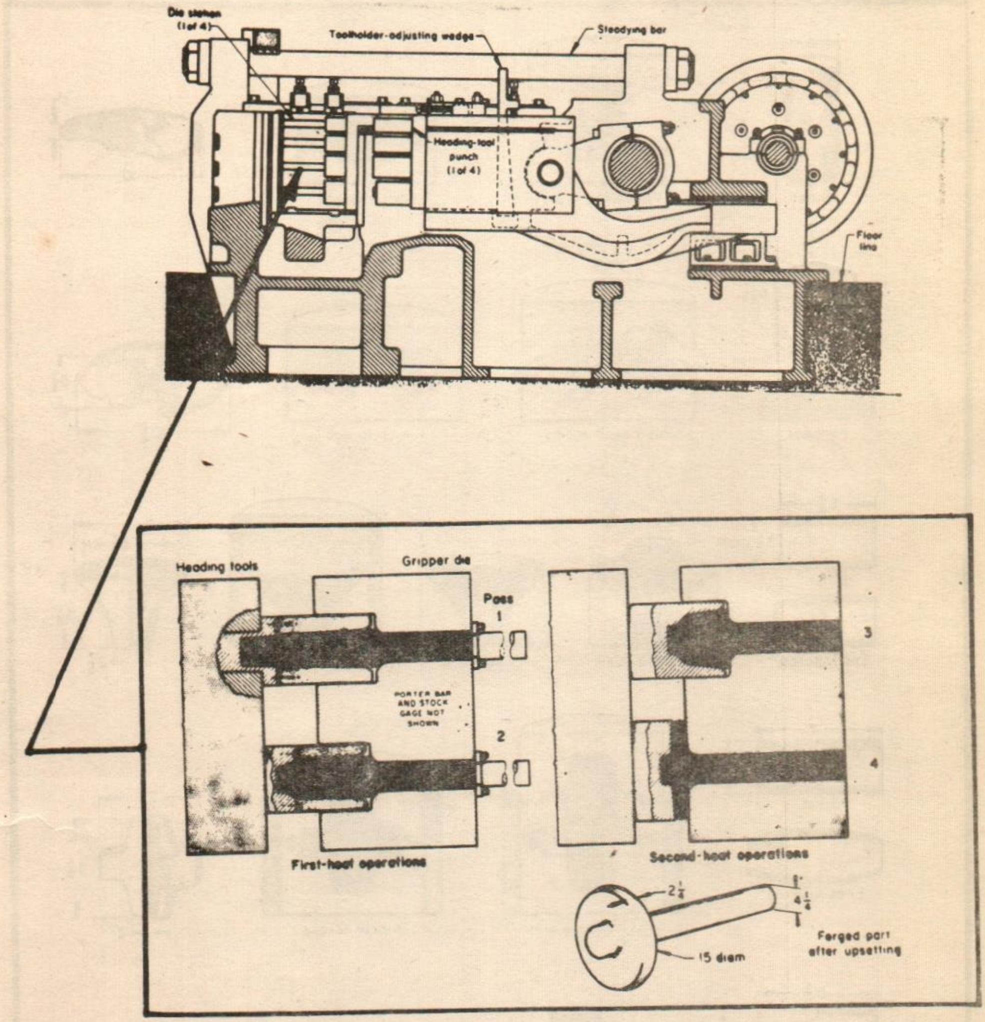

Fig. 2 : Upset Forging System and Die Assembly

readily extruded. Most press forgings are symmetrical in shape, having surfaces which are quite smooth and provide a closer tolerance than obtained by a drop hammer. Therefore, sizing operations are not needed in the press forging process. Some limited examples are shown in fig. 3.

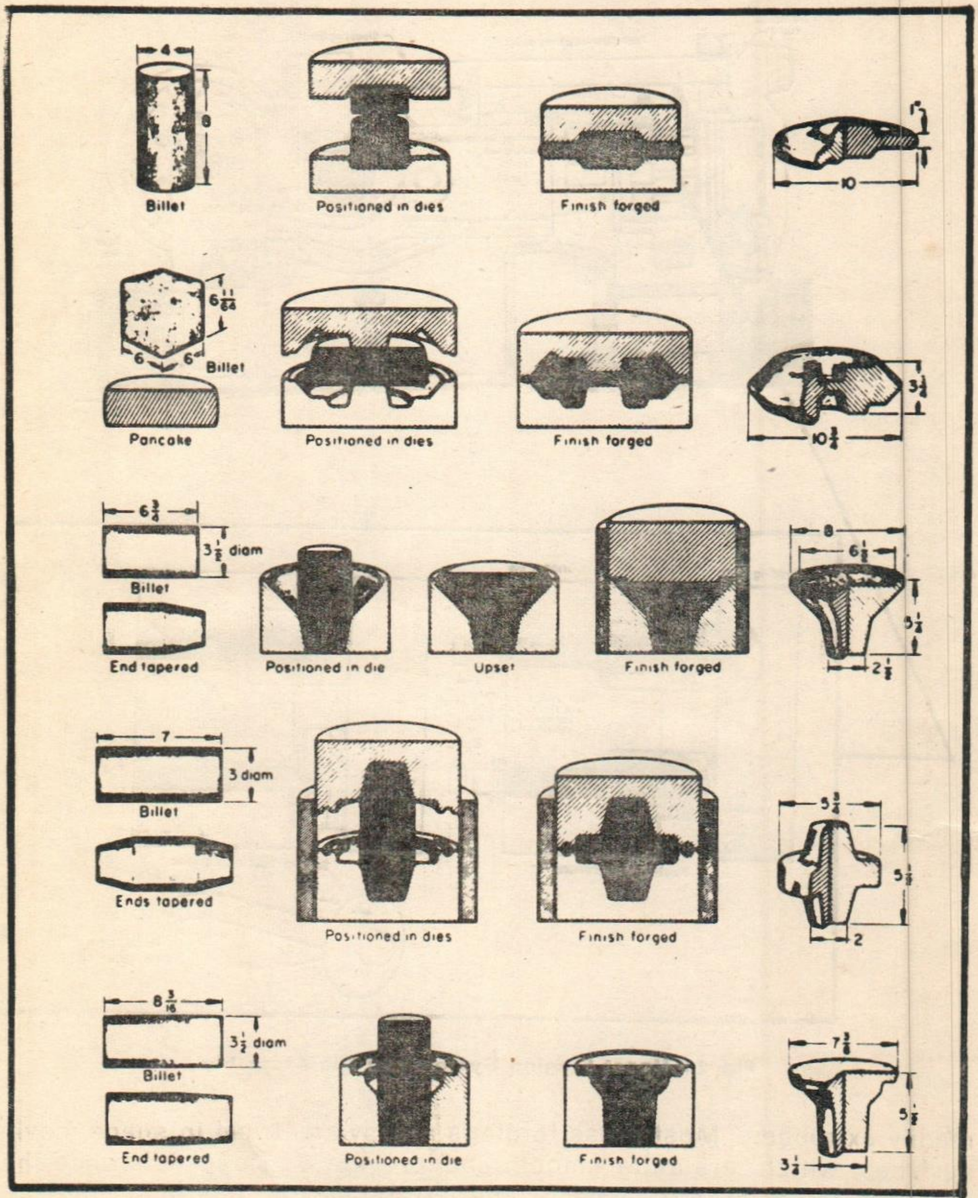

Fig. 3 : Examples of Forging Operations

Roll Forging

Roll forging machines are primarily adapted to reducing and tapering operations on short lengths of bar stock. The rolls on the machine are not completely circular but have from 50 to 75 percent cut away to permit the stock to enter between the rolls. The circular portion of the roll is grooved according to the shaping to be done, as shown in Fig. 4. When the rolls are in open position the operator places the heated bar between them, retaining it with tongs. As the rolls rotate, the bar is

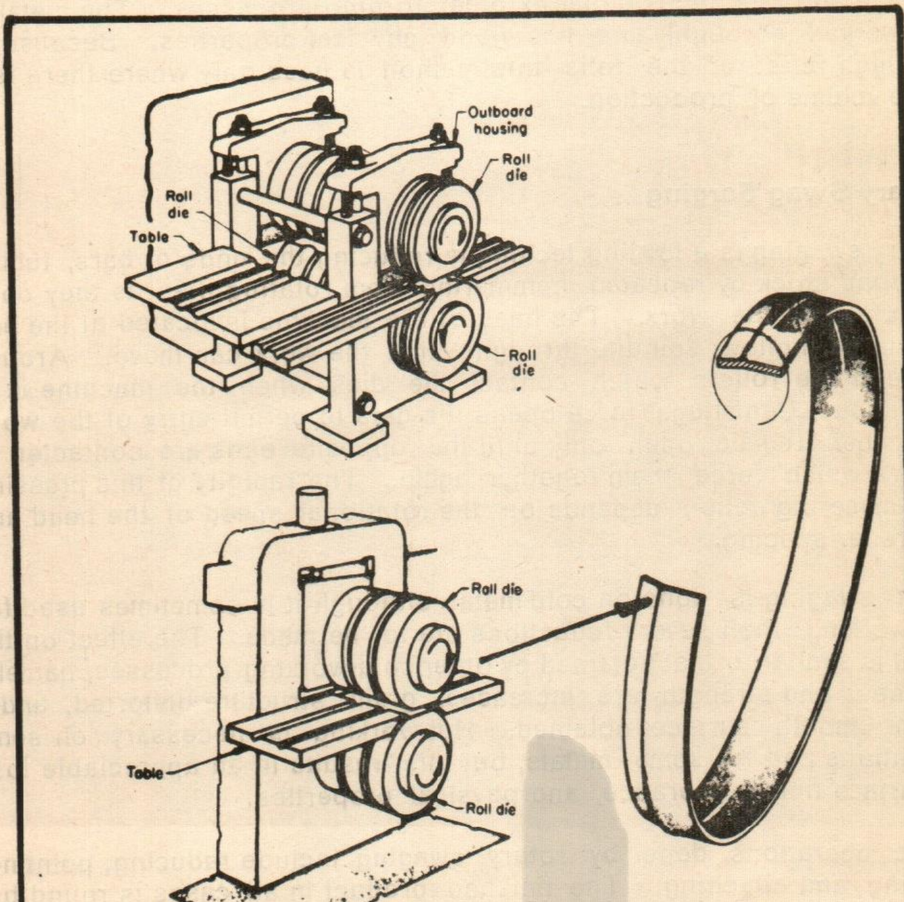

Fig. 4 : Roll Forging System, Die Assembly and Workpiece

gripped by the roll grooves and pushed toward the operator. When the rolls open, the bar is pushed back and rolled again or is placed in the next groove for subsequent forming work. By rotating the bar 90° after each roll pass, there is no opportunity for flash to form.

Examples of roll-forged parts include axles, crowbars, knife blades, chisels, tapered tubing, and ends of leaf springs. This method is often used to supply single preform shapes for subsequent forging by other forging operations. Parts made in this fashion have a smooth-finished surface and tolerances equal to other forging processes. The metal is hot-worked thoroughly and has good physical properties. Because of the high cost of the rolls this method is used only where there is a large volume of production.

Rotary Swag Forging

Rotary swaging is a forging technique reducing the ends of bars, tubing or round stock by repeated hammering from rotating dies as they open and close on the work. The head of the machine is located at the end of a large hollow spindle through which the work can move. Around the end are rollers which contact the dies when the machine is in operation. Centrifugal force opens the dies to permit entry of the work; they then remain open only until the opposite ends are contacted by rollers which force them together again. The rapidity of this pressing or hammering action depends on the rotational speed of the head and the roller spacing.

Most swaging is done on cold metal although it is sometimes used for hot-working when severe reductions are to be made. The effect on the metal is similar to that obtained by other cold-working processes, namely, hardness and strength are increased, grain structure distorted, and a clean smooth surface obtained. Hot-working is necessary on some operations and for some metals, but this results in an appreciable loss in surface finish, tolerance, and physical properties.

Basic operations done by rotary swaging include reducing, pointing, forming, and attaching. The finished product in all cases is round but the size varies. Examples include pointing bars or valve needles, forming axle ends, gear shift levels, golf club shafts and other tubular parts, and the attaching of fittings to ends of steel cables. By using a stationary mandrel, it is possible to forge hollow tubular shapes. Capacities range from small machines having a maximum work diameter of 1/16" to much larger ones capable of handling stock up to around 6". The production rate of these machines is high.

Forgeable Metals

An almost unlimited variety of forging metals is available in ferrous and nonferrous alloys. The following are general classifications of forgeable metals. An exhaustive treatment may be found in books on forging and metallurgy.

1. Carbon Steels:

   (a) Low-carbon (up to 0.25%) forgings for moderate conditions and for carburized parts where resistance to abrasion is important.

   (b) Medium-carbon (0.30 to 0.50%) forgings for more severe service. Some heat treatment is generally desirable.

   (c) High-carbon (above 0.50%) forgings for hard surfaces and for springs. Heat treatment is essential.

2. Alloy Steels (manganese, nickel, nickel-chromium, molybdenum, chromium, vanadium, chromium-vanadium, tungsten, silicon-manganese).

3. Corrosion- and Heat-Resisting and Stainless Steels : Generally, but not necessarily, forged surfaces should be polished to obtain full benefit of corrosion-resisting properties.

4. Iron : Either wrought iron or ingot iron is forged for special applications where ductility is required. Wrought iron furnishes a moderate degree of corrosion resistance. The copper-bearing irons and low-carbon steels are in this class.

5. Copper, brasses, and bronzes.

6. Nickel and Nickel-Copper Alloys: Pure nickel is forgeable. The alloy of nickel and copper known as Monel metal offers a desirable combination of strength, toughness, and corrosion resistance.

7. Light Alloys (aluminium, magnesium).

8. Titanium Alloys.

It may be noted that any ductile metal can be forged. The kind of material is selected primarily for its ultimate properties in the part, such as corrosion resistance, strength, durability, and machinability. The forging process is a secondary consideration. It can be used as long as the high tooling cost can be spread over a large number of pieces.

The forming properties of any metal or alloy depend on the temperature of the material :

1. The hot-working range is near the melting point. The working temperature cannot exceed the melting point of any one of the elements of the alloy. Many such alloys can only be cold-worked. Most hot-worked metals do not acquire a permanent hardening.

2. The cold-working range usually is near room temperature. Most metals strain-harden when cold-worked.

3, At low temperatures, steel becomes brittle. Some metals like aluminum, copper, nickel, gold, silicon and platinum remain ductile at all temperatures.

The forging processes work material cold or hot, depending upon the material and its size. The ability to work cold material depends upon its ductility and malleability as indicated by its stress strain curve. The ability to work hot material depends upon its range of plasticity at higher temperatures. The greatest ductility is near the melting point. In general, most materials become more plastic as the temperature increases.

Conclusion

When the production manager specifies a forging or metal-working process, he is usually trying to produce a product with more attractive physical characteristics, such as greater strength, or else to economise on the weight of the finished part, thus saving on material cost.

If a forging is selected, the designer and management must keep in mind the following principles of sound manufacturing design:

1. Plan carefully all draft angles so that the forging can readily be removed from the die and machining costs kept low.

2. Forgings should be designed so as to have a flat plane parting if possible. Equal volumes of metal should be on either side of the parting line.

3. Use generous fillets at all times.

4. Avoid abrupt changes in section thickness.

5. Avoid sections thinner than 1/8 inch.

6. Consider where it will be necessary to hold the forging for machining. Avoid using the parting plane as a location point.

7. Allow sufficient stock on areas that are to be machined. Usually this will vary from 1/16 to 1/8 inch, depending on the size of the forging.

8. Design forgings so that they are supplied with indentations to spot holes that are to be subsequently drilled.

9. Avoid the design of forgings with deep recesses and pockets. Especially avoid complex contoured deep pockets.

10. Locate identification marks on surfaces that do not require machining. □

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Communicating for Effective Industrial Marketing

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If communication is not a critical element in industrial marketing, it is nearly so, for everything an industrial marketer does or says communicates something to the buyer about the product and the company behind it. Before elaborating on the meaning and usage of the term "marketing communication", however, it is thought useful to distinguish it from the word communication that finds its way into oft-repeated phrases like "communicating for results," "inter-personal communication," and so on. Whereas the former is a dialogue between the buyer and seller of a product, the latter covers communication between employees at the same or different levels in an organisation.

What is marketing communication? How, if at all, does it help an organisation that uses it? What are the elements of an effective marketing communication system? What should an organisation do to put one to use? These are but a few questions, answers to which are provided in the present article which also tends to unfold the relevance as well as importance of marketing communication in an industrial selling organisation.

Marketing communication may be defined as a continuing dialogue between the buyer and seller in a marketplace. It is a two-way flow of information regarding the product as well as its price, specifications, distribution, delivery, guarantee, service, and factors that shape a buyer's awareness and buying behaviour towards the product. Another definition of marketing communication, of particular relevance to the management of an industrial selling organisation, is the following. According to it, marketing communication is the process of presenting an integrated set of "stimulii" (information pertaining to the product) to a target market with an intent of evoking a desired set of responses and setting up of channels to receive, interpret and act upon messages from the market for purposes of modifying company messages and identifying new communication opportunities. An organisation, here, is conceived as both a sender and a receiver of messages. Through the

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wide-ranging media available to it, like advertising, personal selling, sales promotion, etc., it unleashes stimulii that provide prospective buyers with information on its products in an attempt to inform or, at times, modify their behaviour towards the products. Conversely, feedback from the target market provides the selling organisation with information for both directing and controlling messages, and brings to surface changes that need to be made in the media, message and content of communication. Little purpose will be served in devising a communication mix and spending huge amounts of money on advertising, sales promotion, etc., if the organisation does not stand to gain from it. The end-objective of marketing communication, therefore, is to send the message across to as many prospective customers as possible, at least cost, in an attempt to increase its sales, profits, as well as satisfaction among customers to desirable limits.

How does marketing communication work? To start with, it transforms buyers from a state of unawareness or even negative reaction to one of positive action. For example, there may be buyers who are not aware of the company's products, or who, for some unknown reason, are deliberately ignoring them. In cases such as these a selling organisation has little choice but to approach the buyer and inform, persuade, or convince him if need be, of the suitability of its products. Benefits that a marketing communication programme brings to the management of a selling organisation are :

i. It bridges information gaps existing among manufacturers, middlemen, and customers;

ii. it coordinates promotional activities of the total marketing system to achieve a coordinated thrust;

iii. it adjusts the system to meet customer requirements; and

iv. it adjusts the product to meet customer needs.

MEDIA FOR COMMUNICATION

Once the purpose of communicating with the target market has been understood, the question that needs to be answered is how best a company can communicate with prospective customers within resources available to it? The four media of communication, also referred to as components of the communication mix, are:

i. the product and its package;

ii. the salesman;

iii. advertising and public relations; and

iv. conversation among customers about the product and the advertising.

The Product and its Package

The product is by far the most important medium for communication and this fact is being increasingly realised and acted upon by industrial selling organisations. Without the right product for a market an organisation can seldom succeed. For example, when delivery is taken of a new car, or when a new machine is received in the tool room, everyone gathers around to see its finish, texture, design and colour. Just by sitting there, the product speaks for itself and acts as a medium of communication in its own right. Although packaging for an industrial product does not have as much bearing on sales as packaging for a consumer product, its place in the total communication-mix cannot be ignored, for damaged goods from an insecure, slip-shod package can mar the image of an otherwise reputable product and the organisation that supplied it.

The realisation of the importance of product as a medium for communication explains why some companies are successful in selling products without spending substantial amounts on advertising. For them the product and its design, package, and price-tag are probably the most important methods of communication. Because of the importance attached to the product in market communication, product design and styling is becoming increasingly important in marketing. Due to rapid technological advances, life-cycles of most industrial products are becoming shorter, so much so that in certain cases a product only two years old can be reckoned to be out-of-date. It is important, therefore, for industrial organisations to keep abreast with technological advances and provide their customers with the most up-to-date product.

The Salesman

The second most important media of communication available to an industrial selling organisation are its salesmen. A buyer's requirements are not difficult to understand. To start with, he needs the latest information on the goods he is likely to use together with their prices. Next he needs a salesman who can make himself available at short notices to provide technical assistance when required. Steps that could be effectively used by salesmen to communicate with prospective customers are :

i. to identify the potential customer;

ii. to qualify customer potential;

iii. to identify the influential; and

iv. to gain access.

In practice, however, industrial selling is more cumbersome, for apart from selling his company's products, an industrial salesman, or sales engineer as one may prefer to call him, must play the role of a market investigator, a public relations officer, and an industrial consultant, all rolled into one. In the present competitive environment a salesman must also ascertain the number of potential customers in his area together with the type and degree of competition prevalent in it, and keep management informed about it. A salesman must also have a sound knowledge of his product. He should know how his product works and how it is likely to fit in with the customer's production programme. He should not just 'sell' his product but should assist the customer in making best use of his resources and increase efficiency by using the product.

As communication is a two-way process, a salesman must not only talk, but listen too. He should avoid using technical jargon in an attempt to baffle or impress the customer, for, if the customer does not understand, the sale is lost even before it is started. A salesman should not think of what he sells to the customer. He should think of how he can help him make a 'better' buying decision. A really successful salesman is one who helps his customer to come to a better buying decision. The task of selling a company's products cannot, however, be left to the salesman alone. If the increasing competition among industrial organisations is an indication, managers too should involve themselves in this job of persuasion and communication.

Advertising and Sales Promotion

Although not as widely used for industrial products as it is for consumer products, the role of advertising and sales promotion in the communication process cannot be ignored. In recent years, industrial advertising has picked up and more advertisements are finding their way into the national press. In addition to advertisements in the press, industrial organisations today spend considerable sums of money on catalogues, brochures, leaflets, exhibitions, conferences and seminars. industrial films and press and public relations.

Advertising is a link between the customer and his environment, the environment in this case being the scores of industrial selling organisations that constantly bombard the customer with high-power advertising. But like other marketing strategy, advertising too is blessed with strengths and weaknesses and it is wise for a company to know these before embarking on a high-power advertising campaign. For example, whereas advertising helps a company in increasing its sales and profits by developing a direct bond with the customer, it cannot get repeat business for a product or service that does not represent value for money to the customer. Nor can it help sell a product or service overnight. The essence of advertising, therefore, lies in its continuity. But advertising costs can be heavy and it is here that an organisation must bring all its decision-making into play. Therefore, before devising an advertising or sales promotion strategy, it is essential for an organisation to earmark its target audiences. Questions that an organisation needs to ask itself at this stage are : What industries or professions form the potential market? Which particular section of the industry is desired to be reached? What level and job function must advertising be aimed at? What will be the cost of reaching the targeted audience? Can we afford it? What benefits will accrue to us from advertising?

Conversation Among Customers

Customers talking amongst themselves are very often the best salesmen for the product. An understanding of the ways by which word-of-mouth advertising works can make this a valuable communication tool. Why do customers talk between themselves? The possible reasons could be to :

i. gain attention;

ii. show connoisseurship;

iii. feel like a pioneer;

iv. have inside information from competitors;

v. suggest status;

vi. spread the gospel;

vii. seek confirmation of own judgement/decision; and

viii. assert superiority.

Word-of-mouth advertising is different from other commonly used methods of advertising in the sense that it is inexpensive and relates to the experiences of those who have used the product in the past. It is hoped that in times to come, more and more industrial organisations shall become aware of word-of-mouth advertising and use it as an effective tool for communication.

Knowing that the choice of the communication mix lies between the above media, an organisation often finds itself in a fix to decide the extent to which the media are to be used. The ultimate combination or "mix" used, however, will depend on the type of product, novelty of product, size of market, size of sales force and distribution channels. A new product may require an equal usage of both advertising and personal selling, with on-the-spot demonstration if possible. A product that has been in the market over a period of time will sell by itself if its performance has been satisfactory, although some amount of advertising may be necessary to keep the customers informed of changes, if any, in the product. In cases where the market is large and widespread, advertising shall hold fort. Whatever be the situation an organisation finds itself in, the role of communication in the success of industrial marketing cannot be undermined. □

Iron Ore Export : Its Relevance for India

Gopal Kadekodi*

Introduction

Dictionaries do not define 'natural resources'. The only way we understand it is as 'non-renewable'. The stock of resources like oil, iron, or copper just does not grow to justify any rate of extraction. Iron ore mining is a case in order for which the technology, market structure, and pricing etc., raise a number of issues both for mining industrialists and economists.

Ore is an inheritance of man; so will always be. Hence, a balance between a resource not exhausted today and not exhausted by a future date is necessary, This makes the study of exhaustible resource distinct as an enquiry in the opportunity cost of this wealth. Depletion of several natural resources can bring about short run and long run shifts in technology and taste. Depletion may not remain a major threat as long as the economic law of factor substitution is viable. Iron ore has, with the present knowledge of technology, only one major use, namely in making steel. Demand for steel is likely to increase continuously at least for replacement if not for growth *via* capital formation. The ore reserves of the Indian sub-continent is estimated to be about 10 billion tons. The present per capita consumption of steel in India is only 27 kg. as compared to 618 kg in USA. Hence, while planning the expansion of this sector in India whether the ore reserves will meet the future growing demand for steel to raise the per capita consumption is an open question.

Is the ore market a model of economists' notion of supply-demand interaction ? World trade statistics indicate that ore is transacted between buyer and seller with three distinct institutional arrangements. More than 40% of ore is moved to the steel plants from their own captive mines. An equal quantum is traded between countries on the basis of long-term contracts only. The trade under long-term contracts are also often backed up by an influx of foreign investment into the ore-

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producing countries. Finally, often trade is restricted between countries falling within certain political identities. Traditionally, about 80% of imports of East European countries are met by the USSR. In all these cases, it is obvious that price is not relevant in determining the supply and demand. Basically, the ore market is guided by the demand for crude steel. Exports of ore from India are increasing at a rate of 5.2% which is much more than with the domestic demand. Yet, India is only a price taker like many ore exporting countries.

The depletion rate, the buyer dictated market structure in ore trading, price competition without any comparative advantage and high social cost of ore are the major issues which prompt curtailment of ore export from India. This paper analyses international and Indian iron ore trade scenario. The social opportunity cost of ore has been estimated from a representative export-oriented Indian mine. It is further argued that levy of additional royalty and cess is relevant to restrict the practice of wastage and exploitation of this exhaustible resource.

Market Structure : International and Indian

The iron ore market in the world is a pre-empted market because of the substantial backward integration through financial participation. In general, the international mineral market can be aptly described as a bilateral oligopsony. Domestic steel plants prefer to have captive mines of their own to suit their time requirement and ore specifications. International steel plants like to assure themselves of iron from other countries with long-term contracts. Both these domestic and international demands are governed by demand conditions for the final products like steel and steel products. The degree of uncertainty in demand for the final products being quite high, the demand for raw materials becomes all the more uncertain. This high uncertainty in demand sparks off some amount of competition among ore producing countries; however, the ore market is basically dominated by oligopsonic forces. This peculiar type of competition in an oligopsonic ore market is further corrupted by the flow of finances from ore buying countries to ore producing countries for mine development, ore dressing and handling. transportation, and development of port facilities. Thus financing of both investment and ore extraction has been a major factor making ore trading only a buyers' diction. Several developed countries like USA, West Germany and Italy have helped Liberia by way of financing and converting the mines as captive sources. Brazil also has emerged as a major exporter of ore through the influx of foreign capital. Some of the recent mine developments in India like the Kudremukh ore are heavily financed by ore buying countries. Even for a developed country like Canada, the growth of the sector is entirely due to US ownership of the mines.

The other major characteristic of this market is long-term contracting. Most countries like Japan and USA have gone in for both heavy capital investment in ore producing countries and for long-term trade deals ranging from 5 to 15 years of duration. Japan, for example, has entered into long-term contracts of over 900 million tons of ore with various ore producing countries. Many of these contracts go up to 1990. The quantity already covered by such existing contracts in 1980, 1985 and 1990 are 89, 50 and 10 million tons respectively.

It is estimated that in 1960's about 40% of world ore transaction took place directly between steel companies and captive mines, another 19% was transacted under long-term contracts upto 20 years, only about 41% of sale operated under free market or short-term contracts. These trade patterns during 1968 changed to 30%, 36% and 34% respectively [1, 107-108]. Today, about 60% of Japanese imports from Australia and Brazil is under long-term contract. Traditionally more than 75% of imports by East European countries is from USSR. Table I shows the trading pattern between ore producing and buying countries in 1973.

One can identify several factors for such a contractual market structure in ore trading. Firstly, the ore buyer would like to ensure guaranteed supply of certain chosen ore type and grade. Secondly, except for USSR, Canada, Sweden and Australia, most other export oriented ore producing countries lack both finance and technical know-how regarding mine development, ore preparation, transportation and port facilities. The capital outlay required in all these activities are enormous. The total capital cost of most of the Indian fully-mechanised mines range from Rs 40 to 80 million per million tonne per annum of installed capacity, with an average of about Rs 73.5 million. The investment cost of a 2 million tonne capacity pellet plant is around Rs 700 million. Thus, the mine developments for export purposes in several developing countries are taking place with financial and risk pooling from the buyers.

Table 1 : Iron Ore Trade Martix : 1973

Producing country	Reserves (Billion T.)	Total Prodn. (M.T.)	Home Consumption (M.T.)	Total Export (M.T.)	Importing Country (M.T.) Japan	East Europe	EEC	USA	Others
Australia	16.17	84.34	10.26	74.08	64.25	0.20	8.60	0.47	0.56
Brazil	30.05	56.02	11.06	44.96	12.82	1.10	11.04	3.27	6.73
Canada	33.63	55.09	17.42	37.67	3.36	—	12.08	21.97	0.26
Chile	0.45	10.00	0.94	9.06	8.49	0.21	0.15	0.21	—
India	8.65	35.56	12.06	23.50	19.11	3.70	0.22	—	0.47
Liberia	0.71	29.80	4.23	25.57	2.45	0.10	18.64	2.78	1,60
Peru	0.97	9.00	—	9.00	6.13	—	1.17	1.53	0.17
Sweden	3.37	34.82	1.53	33.29	0.21	2,00	28.27	0.28	2.53
Venezuela	2.10	23.26	1.60	21.66	—	—	7.22	13.32	1.12
U.S.S.R.	110.48	214.33	172.93	41.40	1.23	35.90	—	—	4.27
U.S.A.	7.62	90.53	133.96	0.63	0.53	—	0.10	—	—
Others	37.26	131.03	25.78	61.19	16.14	2.29	42.53	0.23	—
Total	251.46	773.78	391.77	382.01	134.72	45.50	140.02	44.06	17.71

Source : *Yearbook of International Trade Statistics*, Vol. II, 1974

Thirdly, the political structures in ore buying and producing countries have put further restraint on free trade. For example, 36 out of 46 million tonnes of ore imported by East European countries come from USSR. Finally, the geographical considerations also make trading decisions bilateral and contractual. Japan, for example, finds it cheaper to import from Australia as the transportation costs are lower. Similarly, being closest, almost all the ore produced in Venezuela is exported to USA only.

The Indian ore production is backed up by a mix of both domestic and foreign demand. Over the years the export demand has been increasing manifold as compared to domestic demand. There were about 392 iron ore mines in operation during 1975 of which 18 were captive mines of the domestic steel mills. All the captive mines are large in size. The share of production of captive mines was 34% in 1975. Thus about 4.6% of mines controlled by the domestic steel plants produced about one-third share of total ore. Since most of the steel manufacturing in India is by the public sector undertakings (about 84%), majority of the captive mines are also publicly owned. The public sector owns, in all, 10.4% of mines, of which 3.8% are captive mines of domestic steel plants. However, these small number of captive public sector mines produce 27% of total ore in India. Table 2 highlights some of these market characteristics. The public sector non-captive mines are producing about 16% of ore. Most of these again, cater to the requirements of domestic steel plants. Noticeably, a large number of non-capitve mines (about 90 %) are operated by the private sector, their total production being about 50% of total ore production. These private non-captive mines are mostly export oriented.

Table 2 : Mine Ownership Distribution : 1975

Type of Mines	*No. of Mines*	*Production M.T.*	*% of Mines*	*% of Production*
Captive	18	14.04	4.59	33.90
Non-Captive	374	27.37	95.41	66.10
Public Sector	41	17.56	10.45	42.43
Captive	15	11.07	3.83	26.73
Non-Captive	26	6.50	6.63	15.70
Private Sector	351	23.84	89.54	57.57
Captive	3	2.97	0.77	7.17
Non-Captive	348	20.87	88.78	50.40
Total	392	41.41	100.00	100.00

Source : Indian Bureau of Mines, *Mineral Statistics of India*. April, 1976

India exports about 60% of ore produced, to Japan and European countries. Recent trends also indicate good prospects of Indian export to some of the Middle East countries. Almost all the ore going to Japan and Rumania are under long-term contracts of various durations. The international financial participation in mine development, pelletisation, ore transportation, and port development is quite common between ore-buying and ore-producing countries. However, such financial participation in India is only nominal. Most of the exports from India, however, are based on long-term contracts. India's sale contracts with Japan for 1974 totalled about 22 million tons. The entire pellet export from India is contracted upto 1988. The only major contract with foreign financial assistance is with Iran for an annual shipment of 6 million tonnes of concentrated ore. However, the finance is in the form of loan rather than foreign investment. Characteristically enough, about 15 private mining companies in Goa operate about 158 mines in the size ranges of 0.02—2 million tonnes. This entire Goan ore is exported mainly to Japan. These mining companies enter into trade deals of 5-10 years. There is an element of competition among them, which has kept the price of Goan ore much below as compared to other exported Indian ore and fairly constant over the last one decade.[1]

Indian Export of Iron Ore

Recently, development literature has been focussing, among other things, greatly on the relevance of exploitation of exhaustible resources specifically for exporting. Some of the pertinent questions are : (a) Is it worthwhile exporting ore? (b) Are the less developed countries being exploited? (c) Is cartelisation possible among ore producing poor countries ? The first is a problem of pricing exported ore, while the second raises an issue of depletion and opportunity cost of extraction. The third is a policy question for the mining sector.

It seems that miners in India are looking for greater avenues to export ore in some form or other. The completion of second pellet plant in Goa to export pellets to Japan, the construction of a pellet plant at Donimalai to export pellets are only indications of interests in maintaining export of ore in some form or other. From the demand side, it is estimated

1. See Table 4 for the prices of different ores.

that world export demands in 1980, 85, and 1990 are expected to be 565, 675 and 794 million tons whereas the probable supplies from countries other than India are estimated to be 515, 600 and 710 million tons.[2] Thus, India has a fair chance of improving her exports during the next one or two decades. With such a prospective scope for exporting, the pricing of ore, opportunity cost, and terms of trade will remain important issues.

The performance of iron ore sector can be measured by three major yardsticks namely, (a) its contribution to domestic production, (b) its contribution to employment, and (c) export earnings. Of the three, the last factor has been contributing substantially both towards employment and foreign exchange earnings. Indian production of iron ore is basically nurtured by the trend in export. During the last one decade (1966-76) exports of ore have increased from 51% of production to well above 62%. Presently, Indian exports are of the order of 20 to 25 million tonnes of ore per year.

Among the principal producers of iron ore in the world, the industry in most of the countries except for USSR, USA and France is banking mainly upon exporting ore. India is one among the first eight countries in the world producing iron ore with a share of about 5%. In terms of exports, Indian share in the world market has been around 5 to 6%. In Table 1 a comparative picture of world production and export of ore is summarised. Noticeably countries like Australia, Brazil and Sweden are producing mainly for exporting whereas countries like India, Canada and USSR are using ore both for domestic consumption and exporting. However, India's share of export out of production has been sharply increasing during 70's.

Internationally, India is facing keen competition from a number of countries for her export of ore. The principal buyer of Indian ore has been Japan, the share of which constitutes more than 75% of Indian export. Rumania buys about 10% of our export, the rest being shared by over a dozen countries. With the completion of Kudremukh project, India will start exporting ore to Iran to a tune of 6 million tonnes of concentrates. In addition to this Iranian deal, prospects of Iraq and Saudi Arabia buying from India in the near future are bright. Table 3 shows

2. These estimates are made by Mineral and Metal Trading Corporation of India.

the trend in Indian export from 1971 to 1976. It is important to note the fact that over the years the competition in international export market is increasing considerably. For example. countries like USSR, Australia and Brazil continue to export and their share has been increasing.

Indian export to Japan, even though significant (from India's point of view) is quite small as compared to the total imports of Japan from the rest of the world. On an average Japan imports about 19% of her requirement from Brazil, 48% from Australia and about 12% from Canada, Peru and Chile.[3] Hence India and many other countries are neck to neck in exporting ore.

Apart from this trade competition, the price competition is also quite disturbing. The freight cost from India to Japan is about 42% of Japanese CIF price, whereas the same with Australia is only 20%. The high freight cost is due to not taking advantage of the economies of scale in shipping. In the past (i.e. during 1973-76) the average sizes of ore carriers serviced at various Indian ports varied between 30,000 to 35,000 DWT. The sizes handled by certain major international ore loading ports are above 100 thousand DWT. The average size of an ore carrier in the world was about 80,000 DWT in 1974. However, with the development of mechanised berths at Visakhapatnam and Marmugao ports and outer harbour facility at Madras port, larger ships are expected to handle the ore shipment, reducing the average freight cost.

Apart from the effect of ocean freight cost, our own FOB cost is also increasing during the last 5-6 years due to increase in inland transport cost and port handling charges. The FOB price of lumpy iron ore at Madras was Rs. 89.54/T in 1973 which rose to Rs. 124/T in 1974. Only the FOB price of Goan ore is fairly constant. Table 4 presents a comparative picture of ore prices at different ports and pit heads. Finally, our pit head costs are higher than our near competing countries like Brazil, Chile, Peru, Canada and Australia.

The prevalence of international competition makes Indian position in price bargaining quite weak. The major determinants of Indian exports

3. From the latest statistics of Japanese imports of ore published in *Iron Ore Manual*, The Tex Report Co., Japan 1977, pp. 35.

Table 3 : Major Buyers of Indian Ore

(in million tonnes)

Importing Country	*1971-72*	*1972-73*	*1973*	*1974-75*	*1975-76*
Japan	16.35 (15 03)	18.10 (15.39)	19.11 (14.10)	16.12 (11.81)	17.18 (13.18)
Rumania	1.04	1.32	NA	2.14	2.03
Czechoslovakia	NA	0.81	NA	0.52	0.40
Poland	0.36	0.41	NA	0.45	0.58
Bulgaria	NA	0.15	NA	0.31	0.12
Hungary	NA	0.08	NA	0.14	0.13
Yugoslavia	0.20	—	0.03	—	—
Belgium	0.23	0.19	0.18	0.17	0.04
Netherlands	NA	—	NA	0.72	0.40
West Germany	NA	—	0.01	0.21	0.16
S. Korea	—	—	0.24	0.61	0.61
Others	NA	0.33	NA	0.90	0.86
Total Indian Export	19.29	21.39	21.29	22.29	22.51

Source: (i) *Indian Iron Ore Industry*. Its Market by Economics and Marketing Services of NDMC, January, 1977.

(ii) *Year Book of International Trade Statistics of UN, 1975.*

Note: (i) Numbers in parentheses are % share of Indian Ore in Japan's total import. Source : *Iron Ore Manual*, Tex Report Co. Japan, 1977.

(ii) NA means not available.

Table 4 : Some Recent Trends in Pithead (FOR) and FOB Costs of Iron Ore

(Rs./T)

Grade	*Quality*	*Mine Region*	*1973*	*1974*
		FOR Prices		
Lump	63-65% Fe	Gua (Bihar)	19.30	19.00
,,	61-63% Fe	Gua (Bihar)	17.30	17.00
,,	65-67% Fe	Kirindul (M.P.)	13.67	NA
,,	65-67% Fe	Hospet (Karnataka)	20.00	22.50
,,	65% Fe	Baisankheri (Karnataka)	17.00	21.00
,,	65-67% Fe	Toranagalla (Karnataka)	21.75	25.75
,,	62% Fe	Sauvordom (Goa)	21.75	32.50
,,	60-62% Fe	Bolani (Orissa)	20.36	26.26
,,	65-67% Fe	Banaspani (Orissa)	19.00	20.00
		FOB Prices		
,,	62% Fe	Marmugao	57.88	57.88
,,	58% Fe	Marmugao	44.77	44.77
,,	67% Fe	Madras	89.54	124.44
,,	65% Fe	Madras	80.82	91.28
		Vizag	86.15	88.90
,,	63-65% Fe	Kakinada	70.00	103.54
Fines	60-63% Fe	Marmugao	38.95	38.95
Pellets	60-63% Fe	Marmugao	91.29	143.34

Source : *Index of Mineral Prices in India,* Indian Bureau of Mines, 1975, pp. 55-56.

Note : NA=not available.
FOR=Free on rail.
FOB=Free on board.

are essentially, the level of crude steel production of Indian ore buyers and quantity of ore exported from the rest of the world. The crude non-electrical steel production of Japan has been growing during the last one decade at a rate of 15.5 percent per annum. But Japan has to rely on foreign countries both for her export of steel products and imports of ore and coking coal. Thus, Indian dependency on Japanese imports of ore for the development of this sector is not justified both in terms of quantity of exports and price. An econometric model of Indian export of ore indicates that price bargaining has not been a significant factor in explaining ore export.[4] Demand for Indian ore is basically determined by the level of crude steel production and competitor's supply of ore.

It is anticipated that with the shift in export deals with Iran and several middle east countries the crude non-electrical steel production of Indian ore buyers will increase at a rate of 3.2% during 1976 to 1980, 2.9% during 1980-85 and 2.5% then onwards. Hence, it is estimated that Indian export of ore can continue to increase, reaching about 73 million tonnes per annum by the end of this century. These trends of export and domestic demand (which is expected to grow to about 50 million tonnes per year by the year 2000) raises several issues in planning for this sector. The first question is whether this rate of depletion is sustainable for a country like India. Secondly, what is the opportunity cost of ore, which needs to be considered in planning for this sector's growth.

Depletion and Shadow Pricing of Ore

Natural resources are regarded as heritage of the man. The present rate of consumption of such resources, in all fairness, has been possible only because past generations have foregone the use of them either due to lack of demand or iack of technologies. Demand for natural resources is normally interpreted in terms of its 'use value'. The use value of such resources depends entirely on the technology with which they can be converted into useful goods. Nonetheless, it is never easy

4 A simultaneous equation model of export demand and supply is set up with Japanese CIF price, cost of extraction, export of ore from the rest of the world to countries importing ore from India, and production of non-electrical crude steel as explanatory factors. The CIF price is found to be insignificant as much as the cost of extraction.

to identify the use value of a resource having alternative opportunities. Some of the opportunities are postponable, whereas others are not. Use of water for hydel power generation is perhaps postponable but not from its drinking use. Likewise most of the exhaustible or renewable resources have such inter-temporal allocative values. Demand for some of the natural resources are 'man-made', assuming that sufficient knowledge exists about the opportunity cost between present use and future use. Any such opportunity cost estimate can be based only on the stock of knowledge about existing and feasible technologies. Hence, often miners claim that there is never a shortage of resource but there are shortages of technologies. They also argue that the issue of exhaustibility is only man-made.

The price in the sense of opportunity cost reflects a balance between all the opportunities foregone by the past generations and the opportunities to forego by the future generation, in case the ore is extracted today. Then, can the present market price stand for such an equilibrium? Economists argue that the price is only equilibrium between present demand and present supply. Both these depend upon the available stock of knowledge regarding *extraction* technology and *use* technology. Ironically enough, the social value of an exhaustible resource has to depend not upon any stock of technology at any point of time but on the spectrum of technologies over time regarding both extraction and use of the resource. Thus the social value of a resource be determined by the envelopes of demand structures and extraction cost structures over the life of the resource.

A number of economists argue that price of an exhaustible resource be based on both the extraction cost and its market value. The divergence between the social value and social extraction cost calls for a correction while pricing ore. Charging a rental value for exhausting the resource too sooner than socially justifiable is logical to dissuade exploitation beyond inter-generational equity and property rights. Such a rental can be collected in the form of royalty or cess. Solow and Wan [3, 365] call this rental as a 'degradation' cost, as the usual mining practice is to extract the best ore first, leaving the inferior ore to future generations. The extraction cost is likely to rise over time as mining becomes risky with increasing depth of the ore body and increasing operating costs. There is also the possibility of ore quality becoming inferior. In iron ore mining, for example, drilling costs increase with larger and deeper ore bench; and sooner a crest of blue dust is reached having a low percent of ferrous as compared to lumpy ore. With the costs rising over time, it is likely that the gap between the social value of ore and cost of extraction will decline. This makes the rental adjustment less warranted after some duration of extraction. The rental value on exhaustible resources is relevant only in the initial phases of ore extraction when the divergence between its social value (or social marginal productivity) and social cost of extraction is quite high.[5]

The total iron ore reserves in the Indian sub-continent is estimated to be about 10 billion tonnes, of which about 53% is measured, the rest being indicated or inferred. The Haematite ore is about 80% of total reserve with more than 55% Fe. Almost all of the Magnetite ore is of low grade. The present rate of extraction is about 45 million tonnes per year, mainly of Haematite type. At the present rate of extraction, the reserves may last for about 200 years. However, Indian ore production has been growing in the 70's at an annual rate of 4.5%.[6] At this rate of growth the ore can last for about 120 years. India has perhaps the fifth largest ore reserves in the world. Considering the total reserve and the present rate of extraction, it is fairly safe to presume that depletion is not a major threat for another century. In fact, the growth of iron ore industry began only from the mid 60's. Much of this growth is due to sudden spurt in export of ore. The increasing export demand together with higher export price, still remain the prime motives for the expansion of this sector.

In this early phase of expansion of this sector, what are the social costs and returns of extraction? Hypothetically, it is expected that there would be divergences between these two, calling for a correction by way of imposing a rental or royalty value. Our estimates of social cost and social value (equivalent to social marginal productivity) at the pit head for a representative export-oriented mine in India are Rs 41.11/T and 61.44/T respectively.

5. For a theoretical description of the model see Heal [2].

6. The Fifth and Sixth Five-Year Plans have set the target implying an output growth of about 9.4%.

Table 5 : Costs and Returns per Tonne of Ore

	In Market Price (Rs./T)	In Accounting Price (Rs./T)
1. Export value of ore per tonne at pit head	35.0600	61.4400
2. Present value cost of ore per tonne at pit head	36.9753	41.1052
3. Ratio	0.9482	1.4947

Note : See Appendix for details

These divergences in accounting prices, being to the extent of 50%, is an indication of incentives for higher rate of extraction. Such a gap might persist for several decades before the social marginal extraction costs rise upto the social value of ore. From the point of view of long term planning of this extractive industry, the need for correcting the costs by charging a rental or royalty upto 50% of pithead cost seems necessary for 2-3 decades.[7] Such a charge would ensure inter-temporal balance in ore utilitsation. Even the present value market cost of ore is higher than the pit head market return from exporting ore. Thus, on financial terms, export of ore seems uneconomical at the present situation.

In brief, even though the social value of ore seems to be much higher than the social cost, the financial return from exporting ore does not seem to be a reasonable terms of trade if India has to continue with exporting ore. Secondly, Indian share of exports in the world market being what it is (about 5%), the price bargaining does not seem to be effective. Thirdly, with the recession in the world steel demand, ore exporting countries will be facing largest economic setback and uncertainty in trade. Hence, planning for expansion of this sector purely

7. This is so because while arriving at the costs, the discounting has been done for 21 years assuming the life of the mine to be of that order.

for exporting ore will be both uneconomical, risky and unjustifiable on the basis of inter-generational equity. Finally, even for utilising the resource to meet the domestic demand, charging a royalty or cess substantially higher than the present rates seems to be necessary as an efficient pricing policy.[8]

Appendix

Estimation of costs and returns : Donimalai Mine in India

The mine is proposed to export the entire ore (both lumps and fines). The financial costs of investment and ore extraction along with estimated social costs are shown below :

Year	*Financial cost (Rs. million)*	*Social Cost (Rs. million)*	*Ore Production (million tonnes)*
1973-74	137.2	177.19	0
74-75	48.0	61.98	0
75-76	48.1	62.11	0
76-77	103.0	132.99	0
77-78	79.1	56.10	0
78-79	28.58	27.86	2.0
79-80	42.87	41.79	3.0
80-81	51.44	49.39	3.6
94-95	51.44	49.39	3.6

The social cost is based on (a) accounting price of unskilled labour (0.66 is the ratio of accounting price of labour to market wage rate) (b)accounting price of foreign exchange (1.25 is the premium), (c) accounting price of savings. At a social discount rate of 12%, the present value cost of ore is estimated by taking the ratio of total discounted costs and total discounted ore production. The estimated social and

8. Presently the royalty rates in India are Rs. 2/T on ore containing more than 62% of Fe and Rs. 1.50/T for less than 62% Fe. The fines are charged a royalty of Rs 0.35/T.

... very much to the ... The pro- ... in rural region, is the fact that the industrial workers living in the rural areas create markets for the agricultural products, mainly perishable goods, which usually give high returns for a unit of labour. This factor is of considerable importance in developing countries where transport and marketing system are not organised or a good infrastructure does not exist. Thus the added value produced by industrial development may directly increase the income and consequently, the purchasing power of the people in the area. The growth of rural industries is a stabilising factor for rural society in all developing countries. The industry provides new on-the-spot employment opportunities for surplus labour released from agriculture and thus dissuades people from leaving the village and seeking their fortunes elsewhere. This would not only stop their move to the already crowded and inhospitable urban areas, but would as well give a new orientation to rural

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private (market) costs are Rs. 41.1053/T and Rs. 36.9753/T respectively. At the FOB selling price of lump and fines, the pithead values are estimated after a justing for rail and port charges, etc. The social value of ore is estimated, considering shadow price of foreign exchange. The returns are Rs. 35.06/T in market prices and Rs. 36.9753/T in accounting price. □

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areas, encourage their growth on healthy lines and bring to them in due course all those facilities that go with modern living.

The basic problem before the country at the moment is how to expand employment opportunities, so that inflow of youth to the employment market can be tackled. For this, there is a need for adopting a new look to the village industries. For balanced economic development it would be necessary to create the maximum productive employment opportunities for rural people in their own surroundings. For integrated rural development one can identify multi-objective strategy with priorities, having some absolute constraints for systematic scientific and integrated use of natural resources to engage people in the area in a meaningful production. The goal programming approach is an appropriate, powerful and flexible technique for decision analysis for modern decision-maker who is burdened with achieving multiple conflicting objectives under complex environmental constraints.

GOAL PROGRAMMING

Goal programming is a linear mathematical technique in which the optimum attainment of goals is achieved in the given environment. The decision environment determines the basic components of the model, namely, choice variables, constraints and objective functions. The objective function of the goal programming problem consists of deviational variables with pre-emptive priority factors Pj's for ordinal ranking and W's for weighting at same priority level.

Let C be a 2m component row vector whose elements are products of P_2 and W such that

$$C = (W_1P_1, W_2P_2 \dots W_{2m} P_{2m})$$

where P_1 $(i=1,2, \dots, 2m)$ are pre-emptive priority factors with the highest pre-emptive factor being P_1 W_i's $(i=1 \dots, 2m)$ are real numbers.

Suppose d be a 2m component column vector whose elements are d^{-1}'s and d^{+1}'s such that

$$d = d_1^-, d_2^-, \dots, d_m^- ; d_1^+, d_2^+ \dots, d_m^+$$

Then the Goal Programming Problem involving multiple-conflicting goals can be formulated as

Min. Cd

sr. $Ax+Rd-b$

$x, d \leqslant 0$

where A and R are $m \times n$ and $m \times 2n$ matrices respectively.

RURAL DEVELOPMENT : GOAL PROGRAMMING APPROACH

The optimum cash subsidy and fund allocation for industrial units coming in the rural or babkward areas in addition to providing incentive for setting up industries in rural areas, should serve the purpose of maximum employment of skilled and unskilled persons in the regions, maximum utilisation of raw material locally produced, power availability, less pollution, etc.

The amount of capital to industrial unit should be linked with top priority to the employment generated, instead of capital emplyed. Thus the main objective should be mass production by the masses for the masses.

Nomenclature

Nomenclature used in the mathematical model is as follows :

m = number of types of industries in given area for industrialisation,

x_j = number of units of industry type j.

a_{1j} = investment needed for one unit of j^{th} industry.

a_{2j} = number of skilled persons required per unit of j^{th} industry,

a^{3j} = number of unskilled persons required per unit of j^{th} industry.

a^{rj} = average quantity required per unit of j^{th} industry to locally produce r^{th} raw material.

$a_{r,j}$ = average quantity required per unit of j^{th} industry, r^{th} raw material not produced locally.

$c_{r,l}$ = cost/unit for locally produced r^{th} raw material required for j^{th} industry.

$c_{ro,l}$ = cost/unit for not produced locally r^{th} raw material requiled for j^{th} industry.

$q_{j,k}$ = quantity of k^{th} product per unit of j^{th} industry.

v_k = Rs/unit, value of k^{th} product in a given region.

D_k = demand of k^{th} product for a given region.

a_j = air pollution per unit of j^{th} industry.

W_j = water pollution per unit of j^{th} industry.

P_j = units of power required per unit of j^{th} industry.

I_j = percentage of local investment by the owner or the society required per unit of j^{th} industry.

t_j = cost/unit transportation cost of raw material not produced locally per unit of j^{th} industry.

a_j = social cost for medical, education etc. per unit of j^{th} industry,

A = Total fixed cost involved.

F = Total investment available.

S = number of skilled persons available.

U = number of unskilled persons to be employed.

R_r = local raw material available.

R_{ro} = raw material not available locally.

D_k = Demand for k^{th} product

A = Air pollution limit.

W = Water pollution limit.

R = Minimum limit of rate of return.

P = Maximum limit of power available.

L = Local Investment available for industrialisation.

Sc = Social cost for medical, education etc.

n = maximum number of years pay back period.

Mathematical Formulation

Constraints for the Model

1. Total Investment (F) : The sum of investment required by all the industries in a given region should be less than or equal to the total availability of the investment, i.e.,

$$\sum_{j=1}^{m} a_{1j}x \leqslant F$$

2. Skilled Persons : The sum of the number of skilled persons for all the industries in a given region should be less than or equal to the total availability of skilled person(s), i.e.,

$$\sum_{j=1}^{m} a_{2j}x_j \leqslant S$$

3. Unskilled Persons: The sum of number of industries times the unskilled persons required for each type of industry must be greater than or equal to the minimum limit fixed for employment of unskilled persons, i.e.,

$$\sum_{j=1}^{m} a_{3j}x_j \geqslant U$$

4. Local Raw Material: The sum of number of industries times the local raw material required for the type of each industry must be greater than or equal to the same minimum limit fixed for utilisation or local r^{th} raw material, i.e.,

$$\sum_{j=1}^{m} a_{rj}x_j \geqslant R_r$$

5. Payback Period: A maximum number of years payback period assigned must be greater than or equal to the number of industries time the fund required for each type of industry divided by the total sales value minus the total raw material cost minus the transportation cost for the raw material not available in region and substract fixed cost also, i.e.,

$$\frac{\sum_{j=1}^{m} a_{1j}\, x_j}{\sum_{j=1}^{m} q_{jk}\, v_k\, x_j - \sum_{r}\sum_{j=1}^{m} a_{rj}\, c_{rj}\, x_j - \sum_{ro}\sum_{j=1}^{m} a_{ro,j}\, x_j - \sum_{ro}\sum_{j=1}^{m} a_{ro,j}\, t_j\, x_j - A} \leqslant n$$

Similarly other mathematical constraints can be given as follows:

6. Locally Not Produced Raw Material :

$$\sum_{j=1}^{m} a_{ro,j}\, x_j \leqslant R_{ro}$$

7. Market Demand :

$$\sum_{j=1}^{m} q_{jk}\, x_j \geqslant D_{k},$$, k for different product.

8. Air Pollution :

$$\sum_{j=1}^{m} a_j\, x_j \leqslant A$$

9. Water Pollution :

$$\sum_{j=1}^{m} w_j\, x_j \leqslant W$$

10. Rate of Return :

$$\sum_{j=1}^{m} r_j\, x_j^{!} \geqslant R$$

11. Bottleneck in Power Supply :

$$\sum_{j=1}^{m} p_j\, x_j \leqslant P$$

12. Local Fund for Industrialisation :

$$\sum_{j=1}^{m} {}_{ij}\, x_i \geqslant L$$

13. Social Cost for Medical, Education etc. :

$$\sum_{j=1}^{m} S_j\, x_j \geqslant S_c$$

Objective Functions

The objective function is to minimise deviations, either negative and positive from set goals with certain "preemptive" priority factors assigned by the planner for employment and industrialisation in rural area in accordance with the policies, existing conditions and their judgements.

NUMERICAL EXAMPLE

Here, programme of rural development takes several aspects into consideration such as (i) maximum employment generation (ii) maximum utilisation of locally-available resources (iii) minimum power consumption and (iv) fixed rate of return on investments.

In order to explain the model more specifically and to keep the model dimensions within reasonable bound, two types of capital investment projects were selected for a particular region. The two types of projects are cotton-based and sugarcane-based industries. Again, for simplicity of the model, the four types of cotton-based industries to produce four different ranges of products and three types of sugarcane-based industries to produce three products are selected for the model. Data for the case is shown in Exhibit 1.

Exhibit – 1

Summary of Rural Economic Development Goal Programming Model Data

Sl. No.	*Activities*	*COTTON BASED PROJECTS* Range 1	Range 2	Range 3	Range 4	*SUGARCANE-BASED PROJECTS* Range 1	Range 2	Range 3
1.	Capital Rs/-	1000	700	650	400	2000	1200	700
2.	Skilled persons	4	3	3	1	5	3	2
3.	Unskilled persons	8	10	9	5	10	5	4
4.	Pollution PPM	40	120	120	140	130	70	70
5.	Power KWH	6	5.5	4	2	8	6	4
6.	Return Rs/-	80	63	58.5	40	240	108	100
7.	Social Cost Rs./-	20	15	12	10	30	20	10
8.	Required units/ Cotton industry (Raw material Locally available)							
9.	Required units/ Cotton Industry (Raw material locally not available).	5	5	5	3	—	—	—
10.	Required units/ Sugarcane Industry (Raw material locally available)	2.5	3.5	1.1	—	—	—	—
11.	Required units/ Sugarcane Industry (Raw material locally not available).	— —	— —	— —	— —	4 1.5	3 5 0.7	3 0.1

Constraints Involved

The following are the constraints selected for the model:

(i) capital available for rural economic development and employment,

(ii) maximum numbers of trained or skilled persons are available for a particular region,

(iii) pollution tolerance limit PPM,

(iv) return on capital,

(v) local capital ratio,

(vi) utilisation of local raw material, and

(vii) demand for different products.

Priority Structure for Goals

In this example, five different priority structure cases have been considered to see the effectiveness of goal programming. The priority structure for cases A,B,C,D,E are given in Exhibit 2.

Exhibit 2

Prieríty Structurers

Sl. No.	*Goals*	*A*	*B*	*Cases* *C*	*D*	*E*
1.	To avoid any additional power units for the projects	I	II	II		
2.	Total return on capital	II	III			
3.	Utilization of local raw material	III			II	III
4.	Generate local unskilled employment	IV	I	I	I	II
5.	Production on cotton product 4 and Sugar Cane product 7			III		
6.	Capital I					

GOAL PROGRAMMING IN ACTION

Priority Structure Case A

As shown in the Exhibit 2 in priority structure A, the top priority is given to avoid any additional usage of power for the projects because of limited availability for the rural area. In the model, the maximum freely available power units are 300 The second priority is return on capital investment for the projects, the total minimum return fixed as

Rs. 6000. The third priority goal is considered as the maximum utilisation of locally-available raw material for the different industries and in the model the locally-available raw materials for each type of industries (cotton/sugarcane) are 100 units as shown in Exhibit 3. The last priority goal is considered for employment generation for unskilled persons with maximum available skilled persons for the region.

The action of goal programming shows that with the maximum available 150 skilled persons for the projects and with other constraints, the only unskilled employment generation will be 375.5: power utilised 262 units, return gained on the capital Rs. 5487 and 94.34% (cotton) 97.14% (sugarcane) local raw material used. The model suggested 51.09 total number of industries for the given priority structure. The distribution of industries for different raw material base is also given in Exhibit 3. The capital invested is only 66.82% of the available finance.

Priority Structure Case B

The top priority is given to unskilled labour, the second priority is given to usage of power and the third priority is total return on investment. In this structure cotton product 4 and sugarcane product 3 are considered the products for the use of general masses for which demand should be met. Local demand of these products is fixed as a minimum level with the constraints, in the model cotton product 4 (Janata cloth) minimum 40 units and sugarcane product 3 (Janata sugar product) minimum 20 units.

The optimum results under above priority structure and absolute constraints are given in Exhibit 3. In this structure the capital required increased to 71.9%, the employment generation for unskilled persons with maximum available 150 skilled persons was increased to 336, pollution was increased to its maximum tolerance limit to 6000 PPM, power required for the projects is also gone up to 277 units, and there is no cosiderable change in return on investment, but the absolute restriction on cotton product 4 and sugarcane product 3 are fulfilled with production of 43.4 and 85 units respectively.

The total number of industries also increased to 61.57. The industries are 4 times more for the sugarcane product 3.

Priority Structure Case C

In this structure the top priority goal is given to the unskilled employment generation, second priority to the use of power units available to the projects and the last priority to demands of cotton product 4, i.e., Janata quality cloth, essential commodity to live in rural area and sugarcane product 3 i.e., the Janata sugar product. The number of skilled persons available increased to 200.

The optimum results show that the capital required 75% of the total available capital, the skilled persons required only 164.3 against available 200 persons, the generation of employment of unskilled persons increased to 360.2, the pollution is at its maximum limit, power consumption is also at its maximum 300 unit limit, return increased to about Rs. 100 and the cotton product 4 produced only 39.75 units and sugar cane product 3 produced 92 units, with 61% and 158.3% of locally available raw material of cotton and sugarcane respectively.

The total number of industries is increased to 65.67. The distribution of industries is given in Exhibit 3 in structure C.

Priority Structure Case D

In this structure, the top priority is given to the unskilled employment generation for the rural area, and the second priority is given to utilisation of locally-produced raw materials. Further, in this structure the pollution tolerance limit is increased to 6500 PPM and power available also increased to maximum of 400 units.

The optimum goal programming result increases the total capital required to 91.6% of total capital, the complete utilisation of skilled persons available for the projects, the unskilled employment jumps to 397, but the pollution is on the maximum limit and power required 382.5 units, the return on capital increases to Rs. 6211, and the utilisation by maximum number of units of locally-available raw materials. The total number of industries increases to 83.86.

Priority Structure Case E

In this structure the planner may not want to play with the healthy atmosphere of rural region. So there is no increase in pollution beyond 6000 PPM and the power is available freely up to any number of units for rural development. The top priority is given to capital available, second priority given to unskilled employment generation and the last priority is to locally-available raw materials.

The optimum results are capital utilisation 90.1% of total capital available, maximum utilisation of skilled persons available. The unskilled employment generated is only 392.5, pollution limit is maximum, the power units required only 375 and return has no significant change from the case D.

The number of industries is 79.2 and the distribution of industries is given in Exhibit 3.

CONCLUDING COMMENTS

The application of goal programming technique to the rural economic development and employment potential demonstrate how best one can plan to have maximum unskilled employment under the bottleneck of power supply, skilled persons available for the project, create minimum environmental disturbances with limited capital available, desired return on the capital and satisfying Janata demand of products for the region. Further, the model can be extended to various other goals as described by the planner, subject to circumstances. It appears that the rural development planning with multiple conflicting goals can be applied very effectively because there are small number of human factors involved in the decision analysis. The greatest asset of the goal programming model is its great flexibility, which enables it to handle variations of the constraints and goals without difficulty. Further, one must take care to ensure that the model is used as a tool only. If properly employed, this particular version of goal programming technique can significantly offer solution to the rural economic problems. □

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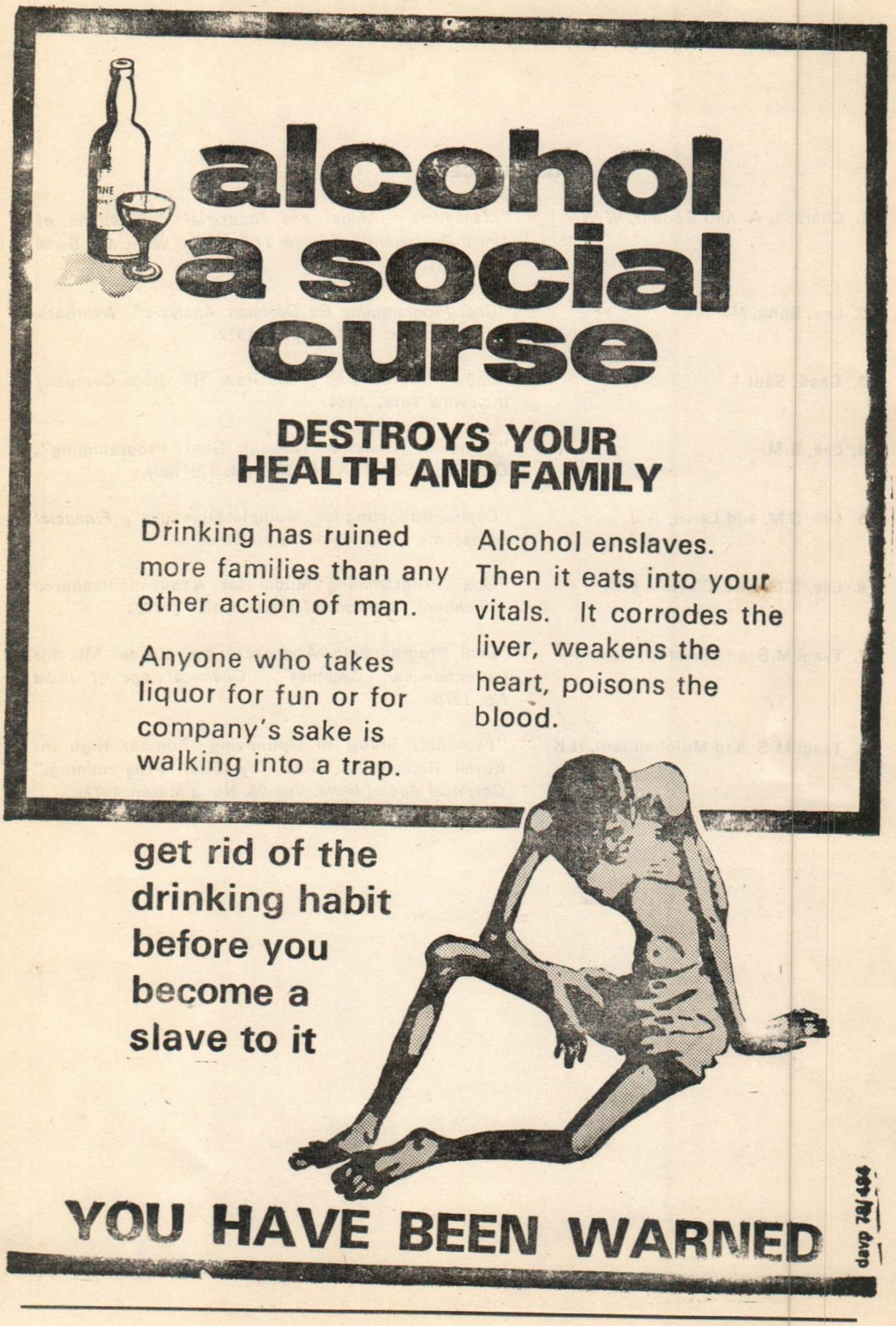
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get rid of the drinking habit before you become a slave to it
YOU HAVE BEEN WARNED
davp 78/494

Variance Analysis in Banks

P. Chattopadhyay*

Variance Analysis : Nature

Accounting for performance variance in banks is an essential part of their exercises in budgetary control underlining budget preparation, targetry, accumulation of information on actuals and sifting the grain from the chaff, orientation of the accounting system towards fulfilling budget targets and norms of operations and exercise of control through analysis and assessment of variances with reference to circumstances and corrective action by way of either removal of snags or revision of targets. This paper makes an attempt to assess the character and size of variances of one zonal office of a bank in a given budget period, embracing its entire gamut of operations and to emphasise the factors that should figure for a close examination. In the light of the facts presented, a checklist is given for consideration of application. Several nationalised banks have adopted the performance budgeting system integrating physical, financial and qualitative aspects of performance.

Significance

This has indeed underlined a new significance of variance accounting and control, particularly for ensuring that budget targets are not only fixed scientifically, but also taken seriously by all those concerned at different levels of operations. The chart that follows is illustrative of typicalities of budgeting and variance accounting, on the basis of tracking down factors that cause variations from targets. The interface between physical and qualitative aspects and between these two and the financial aspects is underlined in this context with particular emphasis on the measurement problem. Considering the typical features of banking functions and the diffused nature of their operations, variance analysis demands a lot more attention than given hitherto. The reasons, therefore, are several, some of which are commonplace while some others are not.

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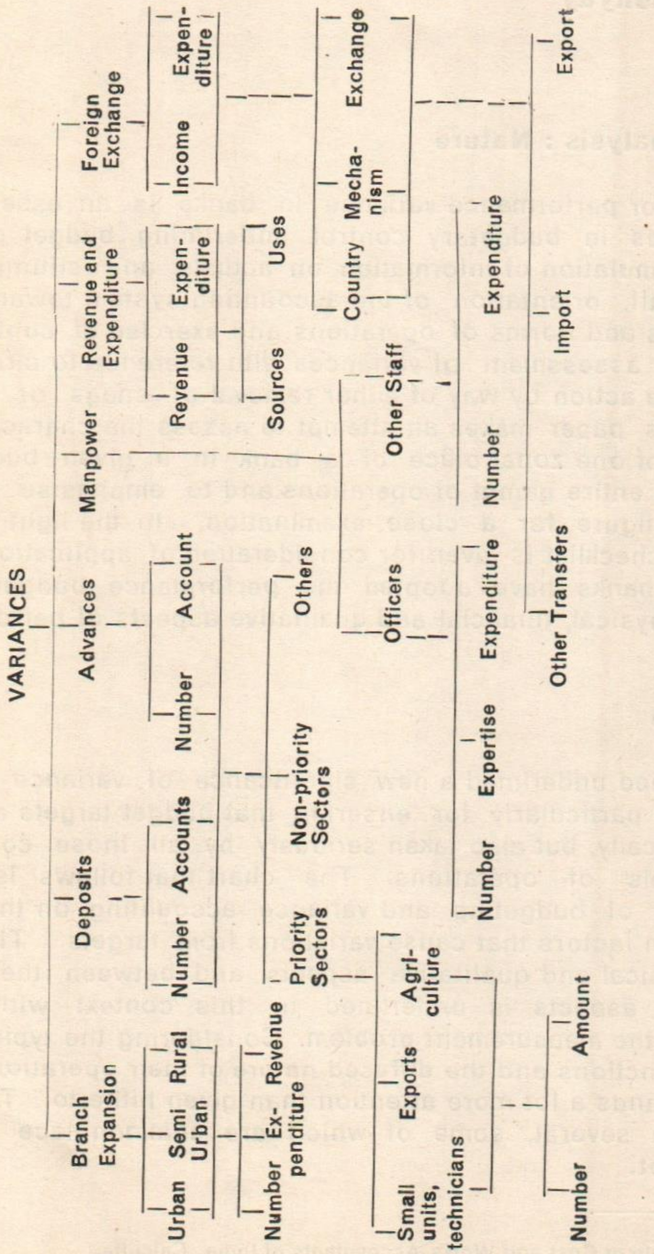

Chart showing Budgeting and Variance Accounting

Controllability

Variance analysis sharpens the budget targets by way of feedback. It helps assessment of whether budgets were unduly optimistic or pessimistic in the context of the resources deployed. It assists management in setting the ongoing budget targets for the year higher or lower in consonance with the experience gained during a shorter span of the budget, acting as a form of monitoring for enhancing the predictability of performance. Viewed as a chain, budgeting implies preparation and adoption of a detailed operating plan, comparison of the actuals with those set forth in the plan and analysis and evaluation of deviations from the plan. Any one of these aspects is capable of setting the whole process at naught, making budgets a fruitless, costly exercise. Consistent over-realisation or under-realisation is to be viewed with equal concern in view of the ineffective predictive mechanism.

Linkages

Linking with factors causing variations from targets and analysis of variances with reference to their character, class and content are essential preparatory steps for initiating corrective action by centres of incidence or responsibility, by appropriate cadres of managers in different functional areas or by the banks themselves or by authorities like the Reserve Bank or the Government in the Union Ministry of Finance, Department of Banking. Controllability varies at different levels stated above and, therefore, the corrective action is required to be taken at an appropriate level, depending on the character of variances, their magnitude and the problems to be sorted out.

Participative Performance Budgeting

All budgets have some degree of management participation inherent in them. The character of such participation differs in letter and spirit in different cases, especially in view of the rather perfunctory approach to this question. A major aim of such participation being the internalisation of targets, underlining that managers take the goals as their own. It is required to be consciously cultivated for any real effect. In most nationalised banks, the exercise of targetry remains more an imposition than an operational requirement, a practical scale of reference. This means that in such cases managers are not adequately motivated towards attaining targets, seek excuses for non-fulfilment and take in adequate care to analysing variances. On the contrary, when managers identify themselves with the targets concerning them, both the targets and the variances therefrom appear in almost a new light.

Nebulous Objectives

This is particularly important for banks in view of the new responsibilities thrust upon them, some of which are rather nebulous while some others are non-commercial and economically non-viable in nature. The objectives behind these activities have to be under constant scrutiny both in the context of target fixing and variance analysis; in several of them non-performance is more profitable and less bothersome. This is curious but true. Participative performance budgeting and variance analysis have special significance for banks to make targets operationally feasible and variance analysis sincere, serious and purposive. The degree of participation is a determinant of success of the performance budgets.

Performance Reporting : A Case

The case presented here relates to the zonal office of a nationalised bank, all figures having been disguised *albeit* their consistency. Table 1 gives the details of deposits which are under the same break-ups as advances shown in Table 2. The actuals and the variances have been juxtaposed, underlining the fact that the branches had a shortfall in realising their targets with respect to agriculture and small scale enterprises while there was a favourable balance in according advances to commercial and institutional clients as also to individuals. In regard to individuals variance was favourable in both deposits and advances. Table 3 provides additional details with regard to new accounts for deposits and advances. In respect of the former, various classes of new deposits and of the latter, advances under various schemes to the priority sector have been underlined in the table. Margins on segmental advances have been presented in Table 4. The composition of earnings and expenses and the net margin provide some interesting sidelights on

Performance Report for the Period January-June 1975
Branch Operations Status

Table 1 / **Table 2**

Deposits: New a/cs opened	Deposits: Number of a/cs	Deposits: Amount	Deposits: Variance		Advances: New a/cs opened	Advances: Number of a/cs	Advances: Amount	Advances: Variance
676	9331	20902	−5558	1. Agriculture (Total)	29	2334	32749	−3637
564 }				— Direct	22 }	2258 }	31164 }	−2851
112 }				— Indirect	7 }	76 }	1585 }	− 786
1542	17485	43723	+5048	2. Small Industries & Small Business (Total)	228	3017	76696	−7616
1971 }				— Small Industries	87 }	1280 }	57771 }	−1946
471 }				— Small Business	141 }	1787 }	18925 }	−5670
720	12122	200763	− 425	3. Commercial & Institutional	139	1721	387467	+16417
17700	283437	562933	+53492	4. Individual	501	3214	25179	+5559
20638	322375	828321	+52557	5. Total	897	10286	522091	+10723

		Liabilities	Assets		
828321	+52557	Deposits	Advances	522091	+10723
3754	− 8643	Borrowings from Banks	Cash Balance	23968	−11372
			Bank Balance	15576	−8450
77494	−22530	Other Liabilities	Other Assets	19008	+2134
909569	+21384	Total	Total	580643	−6965

Table 3 : Supplementary Data

				Deposits New a/cs	Advances New a/cs				
1644	23132	152693	—1118	Current	Under DIR scheme	—	—	—	—
9956	207639	223297	+1756	Savings	Under MSA scheme	160	679	564	—136
9038	91604	452331	+51919	Time	Export Finance	18	157	142522	+17425
20638	322375	828321	+52557	Total					

Note :

Prefix the figures given in 'variance column with (+) sign if the actual amount is more than the budgeted amount (favourable) and (—) sign if the actual amount is less than the budgeted amount (unfavourable)

Example :	*Budgeted amount*	*Actual amount*	*Variance*
	580	610	+30
	690	640	—50

Table 4 : Working Results Status Margins on Segmental Advances

Particulars	Agriculture		Small Industries & Small Business		Commercial & Institutional		Individuals		Total	
	Actual	Variance	Actual	Variance	Actual	Variance	Actual	Variance	Actual	Variance
1. Interest & Discount	2224	—107	3691	—504	19948	+236	1380	+438	27243	+63
2. Commission & Exchange	3	—56	184	—663	5808	—449	18)	—18	6175	—1186
3. Other Income	1	+1	33	—6	45	—33	8	—1	87	—39
4. Total Earnings	2228	—162	3908	—1173	25801	—246	1568	+419	33505	—1162
5. Interest to HO on advances	1474	+163	3451	+343	17436	—656	1133	—250	23494	—400
6. Rebatable Expenses	12	—	—	—	—	—	—	—	12	—
7. Total Expenses	1486	+163	3451	+343	17436	—656	1133	—250	23506	—400
8. Net Margin (Carry over to Table V, Item 1)	742	+1	457	—830	8365	—902	135	—169	9999	—1562

Table 5 : Working Result

	Actual	Variance
1. Net margin on total advances (From table 4, item 8)	9999	−1562
2. Income from non-borrower	806	−903
3. Interest from HO on deposits	33133	+2103
4. Interest from HO on other liabilities	3250	−1247
5. Aggregate earnings (item 1 to 4)	47188	−1609
6. Interest paid on total deposits	23818	−880
7. Interest paid on borrowings from banks	53	+88
8. Interest to HO on assets other than advances	2635	+796
9. Indirect expenses	12698	+1807
10. Aggregate expenses (Item 6 to 9)	39204	+1811
11. Profit (+) or loss (—)	+7984	+202

Table 6 : Advances for the Period 1975

Rs.

Segment	Average				Outstanding			
	Budgeted	*Achieved*	*Variance*		*Budgeted*	*Achieved*	*Variance*	
			mt.	%			*Amt.*	%
AGRI (Total)	36386	32749	−3637	9.9	43000	36048	−6952	16 2
Direct	34015	31164	−2851	8.4	40261	34231	−6030	15.0
Indirect	2371	1585	−786	33.1	2739	1817	−922	33.6
SISB (Total)	84312	76696	−7616	9.0	100500	83300	−17200	17.1
Small Industries	59717	57771	−1946	3.3	71786	61924	−9862	13.7
Small Borrowers	24595	18925	−5670	23.0	28714	21376	−7338	25.5
Comm. & Inst.	371050	387467	+16417	4.4	444500	368800	−75700	17.0
Individual	19620	25179	+5559	28.3	23000	20100	−2900	12.6
Total	511368	522091	+10723	2.1	611000	508248	−102752	16.8
Under DIR	—	—	—	—	—	—	—	—
Under MSA	700	564	−136	19.4	840	613	− 227	27.0
Export Finance	125097	142522	+17425	13.9	150116	137597	−12519	8.3
Total	125797	143086	+17289	13.7	150956	138210	−12746	8.4

Table 7 : Deposits for the period 1975

Rs.

Segment	Average				Outstanding			
	Budgeted	Achieved	Variance		Budgeted	Achieved	Variance	
			Amt.	%			Amt.	%
AGRI	26460	20902	−5558	21.0	33000	19444	−13556	41.0
SISB	38675	43723	+5048	13.0	49000	44400	−4600	9.4
Comm. & Inst.	201188	200763	−425	0.2	253500	202300	−51200	20.2
Individual	509441	562933	+53492	10.5	642000	598300	−43700	6.8
Total	775764	828321	+52557	6.8	977500	864444	−113056	11.5
Current	153811	152693	−1118	0.7	194000	163644	−30356	15.6
Savings	221541	223297	+1756	0.8	279000	233500	−45500	16.3
Time	400412	452331	+51919	13.0	504500	467300	−37200	7.4

the working results of the unit as regards the anticipated results, actuals and variances in each segment. The working results picture emerges more clearly from Table 5. The compositional features of advances and deposits have been shown in Tables 6 and 7, which indicate the variances, in amount and percentage, from the budgeted figures, on average and outstanding. One point has been significant in all these details. If these variances are not communicated to the action points quickly and regularly, they may not serve the purpose and, on the contrary, may create an undue pressure affecting motivation. Depending on their nature, the reporting system should be geared to corrective action. It may, therefore, be expedient that different types of variances may be reported at different intervals and in such detail as may be considered relevant in individual cases. Some of these may be daily, some weekly and some monthly. These may relate to particular schemes or policies, or particular purposes like advances to particular sectors or recovery thereof in proper time.

Staff Position

The staff position of the branches and the zonal office show some rather interesting features. At the levels of branches, on an aggregate, there are 288 officers, 1043 clerks and 586 sub-staff, making for a total of 1917. At the zonal office, there are 83 heads of which 29 are officers, 37 are clerks and 17 are sub-staff. The total strength of the zonal office and the branches is 2000. In planning for staff in consonance with the nature of the new responsibilities, adequate attention does not appear to have been given to strategy-structure interface. For instance, assuming that there exists a hierarchy, the proportion of officers to other staff is rather small. The composite character of the team of officers is not known from the figures presented here. Generally, it has been a common practice that promotees have donned these colours, on the basis of their experience, not expertise. Tradition-bound approaches have been pervasive all along the line. The kind of attitude and intimate appreciation of the requirements of the clients that could have delivered the goods has not been there. Marketing of banking services has not developed in conditions in which the approach is to sell services in response to demand rather than in anticipation thereof.

Providing Wherewithals

Expeditious dispensation of services requires equipping branches with due powers and wherewithal which have remained conspicuous by their absence. On the other hand, engaging in a rat race for opening new branches by these banks has been uneconomic, if not also socially undesirable, while these branches have lingered on ill-equipped to serve the tall orders made on them. After all, banks themselves have not had much say in the matter. That, given the freedom, they would have done something different has been already borne out by the half-hearted attitudes noticeable easily. Government's banking policy mandates indulging in practices not quite warranted by the situation. Variance analysis at the levels of the head office and zonal offices can bring to light factors and forces that have a knack of remaining under the table most of the time.

Rethinking Warranted

The aforementioned details underline the need for scientific socio-economic targetry along with revamped commercial operations. There is a tendency to lean towards profit-earning operations in preference to loss-bearing but socially desirable activities. The nationalised banks, being departmental undertakings, should not have shown this propensity. On the other hand, the structural basis established for implementing the objectives of the Government does not seem to be in step with the functional requirements. The strategy-structure question requires a great deal more attention. Ensuring proper utilisation of assistance extended by these banks demands organised, concerted approaches which are anything but adequate at the moment.

Overdue Advances

The result of all this is perhaps the steadily mounting overdue advances. Such overdue advances may have genuine basis calling for extension of tenure. They may also show indifference and inadequate pursuance towards speedy recovery from the loanees. In certain cases, they may also show that funds were not utilised for the purpose for which these were taken. These are all weaknesses requiring close attention to set them right. It is, however, a common deficiency of most banks. In the case in view, overdue advances for a period of one year or more were of the order of 2565 accounts and Rs 42.5 million. Regarding advances overdue for six months to one year, the number of accounts was 375 and the amount Rs. 3 million. The position is alarming indeed and covers all kinds of borrowers embracing agriculture, small units, individuals and commercial and institutional customers.

CHECKLIST

The checklist may be framed with an eye to the directives of the Government, Reserve Bank of India and the internal management policies as formulated from time to time, providing the parameters within which the objectives of the banks could be defined and delineated. The following questions should be asked and answered in this respect.

1. Are all the areas of performance of the bank defined and identified?

2. Describe these areas as allocated to various departments and levels below each of them.

3. Describe the organisation structure top downward, clearly indicating the interpersonal and interpositional relationships.

4. What are the channels of communication and the chain of command?

5. How are the budget targets decided? Do targets have relation with the span of control? How are these reflected in budget targets?
   (a) Are they parts of a long-term operational plan?
   (b) Are they mooted at the lowest level?
   (c) Are they communicated downwards?
   (d) Are they just left like that? How frequently were targets revised in the past?

6. How are sectional targets integrated stage-by-stage either hierarchically or functionally?

7. How are targets communicated down below?
   (a) Targets disintegrated and made relevant to functional areas
   (b) Targets of capital expenditure of substantial magnitude
   (c) Other functions

8. Is there a budget-centred Information system for reporting variances periodically? Are executives informed of their performance every week, fortnight, month or quarter?

9. What actions are taken on variances? Are these actions reported at levels above?

10. Are these variances weight in fixing targets for the next budget period?

11. Are these variances analysed by causes pointing out extent of controllability with respect to the supervening impossibilities? How quickly are such variances incorporated in revised targets of performance in physical and financial terms?

12. Are inter-branch, inter-zone and inter-bank comparisons made regularly for improving the performance of faltering units?

13. Has any format been designed for such comparison and performance ratios evolved for the purpose of regular and systematic review and appraisal of performance of each of the units?

14. Is there any budget committee for deciding on targets and methods of realising them? Who are the members of this committee? How frequently is the work of the committee reviewed?

15. How are performance accounting, performance budgeting and variance accounting integrated into a scientific system? One primary requirement of such integration is adoption of common heads of accounts for both budgets and accounts vis-a-vis the physical performance in different areas. Has this been done or how is this integration effected?

16. Reporting on bank performance is not entirely internal. For purposes of external reporting particularly to the Government and the Reserve Bank of India, how are the budget and accounting figures incorporated? Is it just that the information as demanded is supplied or is it that banks include additional information assisting in assessment of their performance? How frequently are such reports sent to these outside agencies? Are performance reporting details synchronised with such external reports? □


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Unused Inventories in Central Government Chemical and Pharmaceutical Undertakings

Ram Prakash*

This paper incorporates study of the behaviour of inventories of eleven Central Government undertakings engaged in production of chemical fertilizers, antibiotics, pharmaceuticals, D.D.T. and B.H.C., salt, cement and petro-chemicals. The study covers the period 1966-67 to 1976-77. The names of the eleven undertakings as on 31st March 1977, with their relevant particulars, are given below :

*Rs. in Crores***

	Name of Undertaking	*Year of Incor-poration*	*Paid up capital & Loan as on 31.3.77*	*Profit (+) or Loss (—) After tax during 1976-77*
1.	Fertilizers & Chemicals Travancore Ltd. (control acquired in 1958)	1943	128.60	−13.96
2.	Hindustan Antibiotics Ltd.	1954	10.97	−0.54
3.	Hindustan Insecticides Ltd.	1954	5.62	+0.37
4.	Hindustan Salts Ltd.	1958	1.79	—
5.	Hindustan Organic Chemicals Ltd.	1960	14.96	+3.29
6.	Fertilizer Corporation of India Ltd.	1961	1109.95	−34.45
7.	Indian Drugs and Pharmaceuticals Ltd.	1961	116.73	+4.32
8.	Sambhar Salts Ltd.	1964	1.09	−0.27
9.	Cement Corporation of India Ltd.	1964	54.78	+0.01
10.	Madras Fertilizers Ltd.	1966	62.40	+3.36
11.	Indian Petrochemicals Corporation Ltd.	1969	263.39	+7.49
	TOTAL		1770.28	−30.38

During the period of study, the undertakings in chemicals and fertilizers have grown both in size and number. In 1966-67 there were 7 under-

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**One crore = 10 million

takings in commercial production. They had employed capital of Rs. 125.29 crores and a total turnover of Rs. 51.93 crores. In 1976–77 the capital employed increased by 574 per cent to Rs. 719.37 crores and turnover by 10.7 times to Rs. 556.35 million.

Level ot Inventories

The average inventories held by all the enterprises in this group have increased from Rs. 24.12 to Rs. 213 99 crores over the period 1966-67 to 1976-77. The cost of sales during the period increased from Rs. 47.26 to Rs. 548.5 crores and the inventories as percentage of value of produce fell from 51 to 39. The data on total inventories and cost of sales have been given in Table I and graphically presented in Figs. 1 and 2.

Table 1

Year	Rs. in crores		%age of Inventories to Cost of Sales	No. of Months	Stock Turnover Ratio 2÷3
	Cost of Sales	Value of Average Inventories		Inventories in terms of Months of Cost of Sales	
1	2	3	4	5	
1966-67	47.26	24.12	51.0	6.1	1.96
1967-68	58.03	33.02	56.9	6.8	1.76
1968-69	74.65	44.89	60.1	7.2	1.66
1969-70	105.29	52.99	50.3	6.0	1.98
1970-71	134.29	58.06	43.2	5.2	2.31
1971-72	175.26	65.64	37.5	4.5	2.67
1972-73	194.84	75.12	38.6	4.6	2.59
1973-74	239.28	90.72	37.9	4.5	2.64
1974-75	380.41	132.72	34.9	4.2	2.85
1975-76	461.35	186.68	40.5	4.9	2.47
1976-77	548.50	213.99	39.0	4.7	2.56

During the period of study inventory turnover ratio was highest at 2.85 in 1974-75. In 1975-76 it fell to 2.47 and was at the lowest in the last

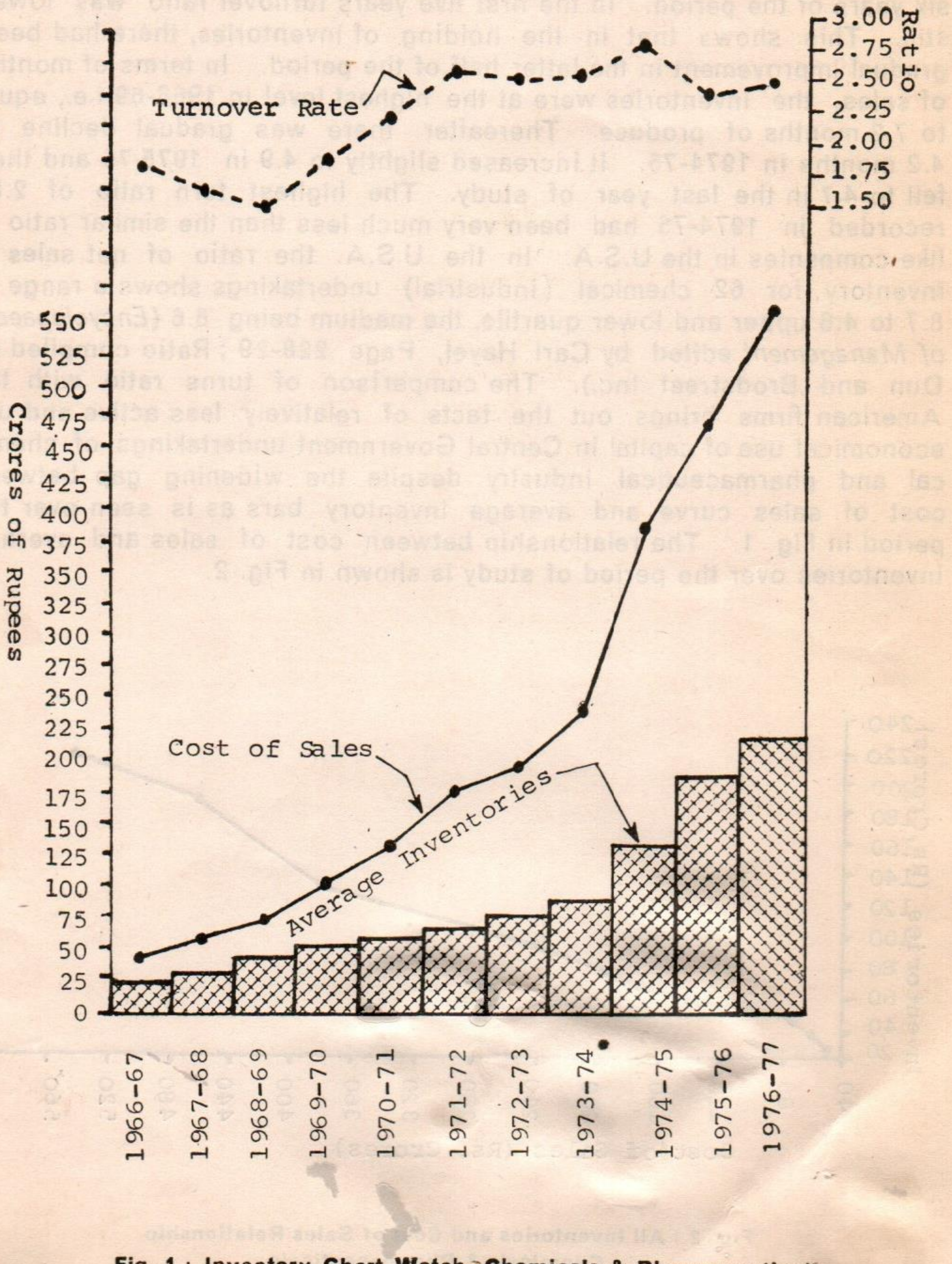

Fig. 1 : Inventory Chart Watch—Chemicals & Pharmaceuticals

six years of the period. In the first five years turnover ratio was lower still. This shows that in the holding of inventories, there had been gradual improvement in the latter half of the period. In terms of months of sales, the inventories were at the highest level in 1968-69 i.e., equal to 7.2 months of produce. Thereafter, there was gradual decline to 4.2 months in 1974-75. It increased slightly to 4.9 in 1975-76 and then fell to 4.7 in the last year of study. The highest turn ratio of 2.85 recorded in 1974-75 had been very much less than the similar ratio of like companies in the U.S.A. In the U.S.A. the ratio of net sales to inventory for 62 chemical (industrial) undertakings shows a range of 8.7 to 4.6 upper and lower quartile, the medium being 6.6 (*Encyclopaedia of Management* edited by Carl Hayel, Page 228-29 ; Ratio compiled by Dun and Brodstreet Inc.). The comparison of turns ratio with the American firms brings out the facts of relatively less active and uneconomical use of capital in Central Government undertakings of chemical and pharmaceutical industry despite the widening gap between cost of sales curve and average inventory bars as is seen over the period in Fig. 1. The relationship between cost of sales and average inventories over the period of study is shown in Fig. 2.

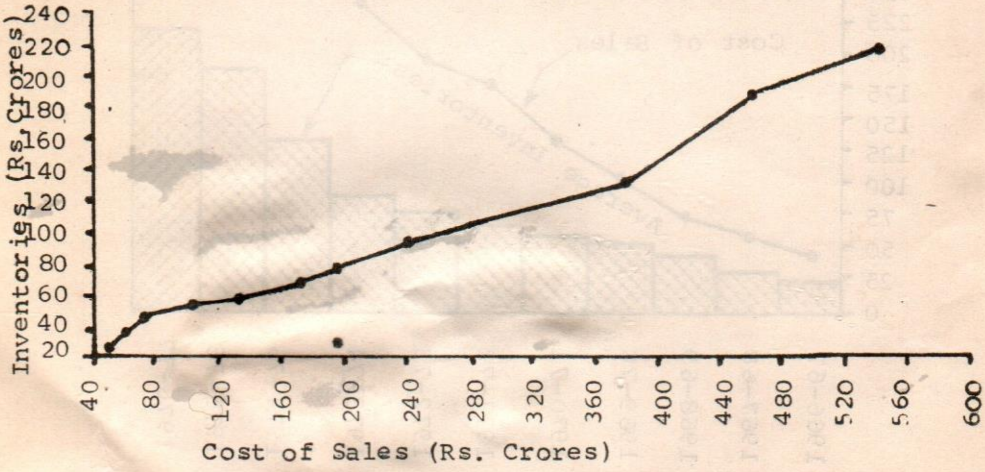

Fig. 2 : All Inventories and Cost of Sales Relationship —Chemicals & Pharmaceuticals

Comparison with Private Sector Enterprises

Comparable data on inventories and cost of sales of large-sized Indian chemical companies in private sector, are available through a study made by Reserve Bank of India. The study relates to 385 joint stock companies, each with paid-up capital of Rs. 1 crore or above. Out of 385 companies, 61 belonged to chemical group and 37 of these were engaged in production of industrial chemicals. The relevant data in respect of these two groups of enterprises are reproduced below in Table 2.

Table 2

Year	*Rs. in crores* Cost of sales		*Value of average inventories*		*In Months* Inventories in terms of months of sales		*Turns rate*	
	All Chemical Companies	Basic Industrial Chemical Companies	All Chemical Companies	Basic Industrial Chemical Companies	All Chemical Companies	Basic Industrial Chemical Companies	All Chemical Companies 2+4	Basic Industrial Chemical Companies 3+5
1	2	3	4	5	6	7	8	9
1971-72	623.27	299.45	195.94	107.07	3.77	4.29	3.18	2.80
1972-73	688.12	333.73	219.22	119.45	3.82	4.30	3.14	2.79
1973-74	774.38	400.39	240.80	133.86	3.88	4.01	3.09	2.99
1974-75	1143.12	624.44	322.33	183.78	3.38	3.53	3.55	3.40
1975-76	1343.11	761.27	409.17	240.96	3.66	3.80	3.28	3.16

The private sector undertakings in industrial chemical group carried stocks equal to 3.53 to 4.30 months of sales and in all chemical group these were equivalent to 3.38 to 3.88 months of cost of sales. The corresponding figures of public enterprises in 1971-72 to 1975-76 were 4.2 to 4.9 months of produce. The inventory turnover ratio of public enterprises in the said five years was lower than those in large-sized private sector companies engaged in production of chemicals. It shows that private sector enterprises carried lesser stocks to cover larger volume of sales as compared to public sector undertakings.

Inventory Components

To identify the behaviour of different components of inventories, the data on stocks of crude materials and spares, work-in-process, and finished goods, consumption of materials and cost of sales, and their appropriate ratios have been summarised in Table 3. The inventories of materials in relation to their consumption and those of WIP and finished goods in relation to cost of sales have been graphically depicted in Fig. 3, 4 and 5.

Table 3

Year	Cost of Sales	Value of Materials & Spares Consumed	Rs. in crores: Average inventories of Raw Materials & Spares	Work-in Process	Finished Goods	Turns Rate: Materials & Spares to its Consumption 3÷4	Finished Goods to Cost of Sales 2÷6
1	2	3	4	5	6	7	8
1966-67	47.26	23.11	18.68 (9.7)	0.87 (0.2)	4.57 (1.2)	1.24	10.34
1967-68	58.03	28.38	24.75 (10.5)	1.35 (0.3)	6.92 (1.4)	1.15	8.38
1968-69	74.65	39.86	32.36 (9.7)	1.93 (0.3)	10.60 (1.7)	1.23	7.04
1969-70	105.29	55.83	34.97 (7.5)	2.49 (0.3)	15 53 (1.8)	1.60	6.78
1970-71	134.29	69.85	37.20 (6.4)	2 86 (0.3)	18.00 (1.6)	1.88	7.46
1971-72	175.26	87.68	44.35 (6.1)	3.38 (0.2)	17.91 (1.2)	1.98	9.78
1972-73	194.84	92.12	52.58 (6.8)	4.84 (0.3)	17.70 (1.09)	1.75	11.00
1973-74	239.28	127.83	62.17 (5.8)	8.18 (0.4)	20.37 (1.02)	2.06	11.77
1974-75	380.41	206.85	80.46 (4.7)	13 88 (0.4)	38.38 (1.2	2.57	9.91
1975-76	461.35	246.91	94.58 (4.6)	18.80 (0.5)	73.30 (1.9)	2.61	6.29
1976-77	548.52	459.01	107.91 (2.8)	14.83 (0.3)	91.25 (2.0)	4 25	6.01

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