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STUDY ON INDUSTRIAL PROJECT IMPLEMENTATION

PROBLEMS ENCOUNTERED IN IMPLEMENTING INDUSTRIAL PROJECTS IN DEVELOPING COUNTRIES *

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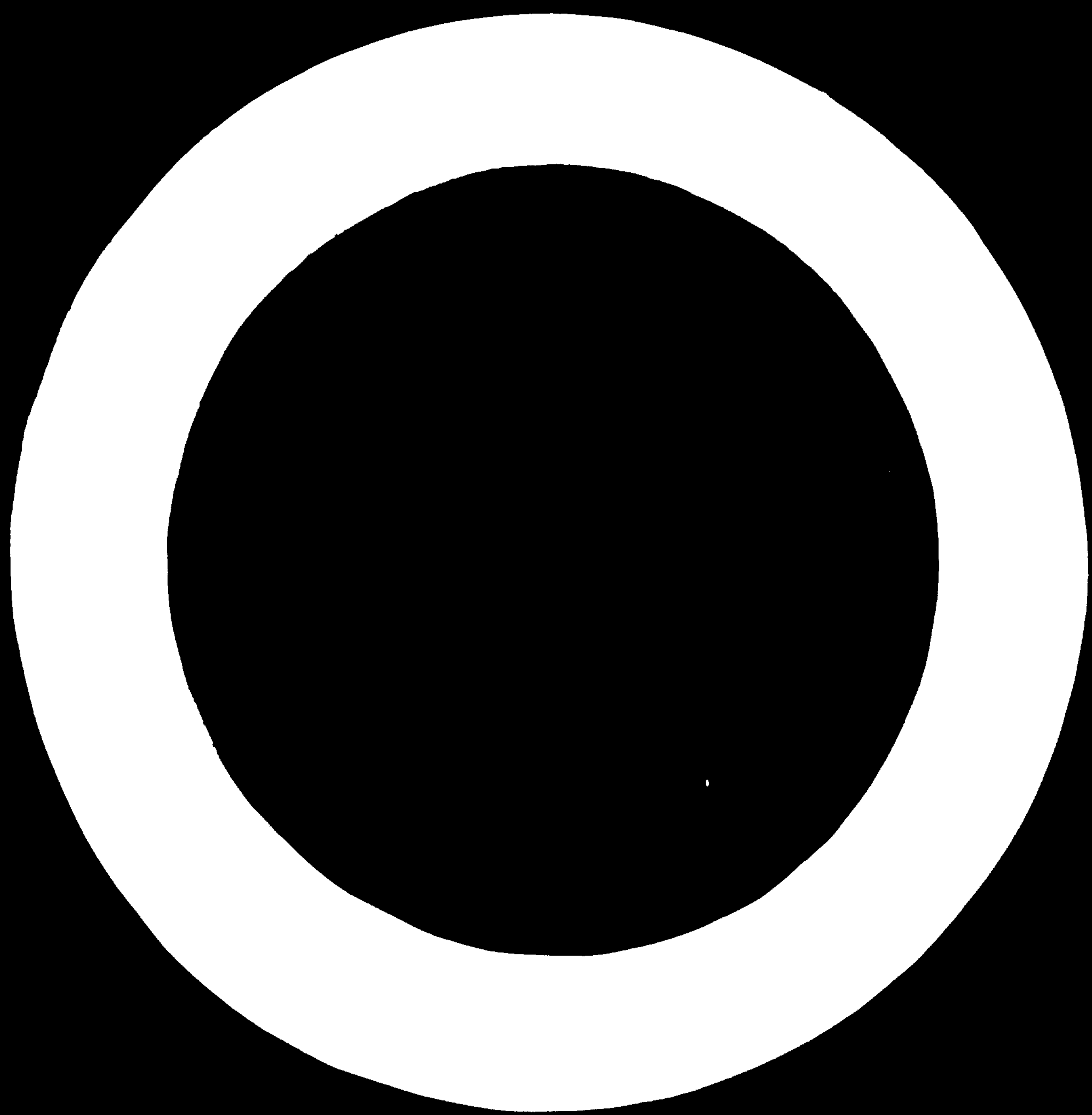
This Study has been prepared for the Industrial Programming Section of the United Nations Industrial Development Organization [UNIDO], by Professor Maurice D. Kilbridge, Graduate School of Business Administration, Harvard University, Boston, Mass., U.S.A.

C O N T E N T S



PROBLEMS ENCOUNTERED IN IMPLEMENTING INDUSTRIAL PROJECTS IN DEVELOPING COUNTRIES

This paper analyzes the problems most frequently encountered in the implementation of industrial projects in developing countries. It has been said time and again that, although industrial development planning is generally well done these days, plan implementation is almost as generally not. Yet the industrial development literature is crowded with books and articles on planning, and quite lacking in anything on implementation. The intent of this study is partially to redress this imbalance.

The implementation phase, for the purpose of this paper, is taken to be the work starting with detailed project planning and design, through construction, to the time when the project is functioning in a satisfactory manner. Thus, the decision to invest is assumed to have been made; the product, general process, scale, market, financing method and general location have been decided upon. Government approval is assumed, at least in principle, and the investment funds, including foreign exchange, are assumed to be allocated and available. At this point implementation begins. It includes site selection, detailed design of the project to accommodate it to the site and to final engineering changes, bidding, contracting and procurement, construction and start-up.

The problems of implementation do not differ markedly between private and public projects. Private projects may, on the one hand, experience greater difficulty in obtaining approvals and allocations, especially of foreign exchange; but the public project may, on the other hand, suffer more from organisational confusion and delays in decisions. All in all, their problems are perhaps about equally burdensome. This paper includes both public and private sectors without distinction, except in detail, as noted from time to time.

Most of the problems discussed here are those encountered by large-scale industrial projects of the size that show individually in national economic planning. These are the projects whose delay can upset a development programme or whose costs, when excessive, can disturb a national budget. It is also the most visible sector of industry, and most politically dangerous if mishandled. The whole world can see a half-built steel mill, to the embarrassment of those responsible. The medium- and small-scale projects, although no less important to national development when taken together, individually present fewer implementation problems than do large-scale projects. They rely less on foreign exchange and imported technology, tie up less capital during construction and are less likely to attract criticism and interference. Nevertheless, some problems of this sector will be discussed and suggestions made for their solution.

Although the problems discussed here will differ somewhat from country to country, they will be more marked by their general applicability to all developing countries. This is because the origins of the problems, the sources of their roots, are the same, and are to be found in the very definition of "developing country". The poverty of means and skills, the lack of foreign exchange accompanying dependence on foreign equipment and technology, the absence of an industrial base, these are at the source of implementation problems, and they are common characteristics of practically all new nations. In the analysis of problems that follows, no distinction has been made, therefore, on the basis of country. We start with a discussion of some common problems that cause delay and then proceed to analyze the cost of these delays.

SOURCES OF DELAY

The implementation work of an industrial project divides, roughly, into three phases: 1) project planning, including site selection, detailed engineering design and cost estimating; 2) the bidding, contracting and procurement cycle and 3) construction and start-up. These are, of course, highly interrelated activities. Oversights in project planning can cause delays in construction. Poor contracting procedures may lead to inefficient and costly start-up. With this inter-relatedness in mind, we shall use this three-phase division of work as the principle for organizing the great variety of problems encountered in the implementation of industrial projects in developing countries.

Project Planning

Much thought has been given over the past several years as to how developing countries can achieve the most efficient allocation of their scarce resources, and considerable skills have been developed in the selection of the potentially most profitable projects from among an array of alternatives; but in the planning of individual projects the wise and frugal use of capital, especially foreign exchange, is sometimes not given adequate attention. This oversight, where it occurs, may be a source of problems that bedevil the project throughout its implementation phase.

Over-capitalization is, perhaps, the most frequent of these errors. Local costs of labour and capital are not realistically appraised before mechanized systems and other capital intensive production methods are imported from abroad. Economies of scale are not well understood; some products are economically produced only for vast markets and are better imported until the market grows. Imbalance of production facilities can lead to parts of a plant being perpetually under-used. Failure to estimate the market correctly may lead to over or under capacity. The economic consequences of locating the project in a less than the most convenient place are frequently not defined and measured. Adequate attention is sometimes not given to assure that the manufacturing process employed is technically stable, and yet not in danger of obsolescence.

Hackney makes the point forcefully when he writes:

> The success of a capital investment is irrevocably determined during the relatively short and usually hectic period between its inception and initial productive use. During this period its value is established. The location of the facility, the products it is capable of making, the process it uses, the type and quality of equipment, the efficiency of layout — these and similar project decisions will strongly affect operating costs and income throughout the facility's potential working life of ten to fifteen and more years. It is therefore important to ensure, as far as may be possible, the correctness of capital investment project decisions. 1/

An illustration of the quality and intensity of planning that is required if subsequent implementation problems are to be avoided is provided by the procedures of a Dutch Company 2/ that has established several plants in developing countries. Factories are adjusted both in product and manufacture to the economic scale, labour supply and skill of the host company. A pilot operation in Utrecht stimulates the manufacturing methods to be used in the subsidiary; manufacturing methods are designed to suit the local situation, sometimes with the result

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1/ Hackney, John W., Control and Management of Capital Projects, New York: John Wiley & Sons, 1965. p.4

2/ "Old Fashioned Technology in Developing Lands", Business International, Feb. 10, 1967. p.47

that methods, previously thought antiquated, are used. Plants can be put into operation on location with amazing rapidity; the Congo plant was built in a week and put into operation four days later.

Inadequate estimating procedures are another prime source of errors in the planning phase. Cost estimating for capital projects is a complex and difficult process. Failure to adjust cost elements to the local conditions of developing countries, and to consider the relationship of project costs to delays in implementation, perhaps account for the majority of estimating errors.

A full discussion of estimating procedures is beyond the scope of this paper, but the following items suggest potential sources of under-estimation:

- Additional costs of remote site, including power source, other utilities, construction colony, freight costs and roads.
- Cost of first-time effort is always higher than subsequent similar projects because of learning effect.
- Difficulty of anticipating at the time of the estimate all of the installations and features required to accomplish the purpose of the project.
- Labour estimates must be adjusted to local productivity and manning patterns.
- Strike and work stoppages.
- Cost of ancillary construction and services must be included in plant cost (such as, housing colony, auxiliary power source, fire protection and security).
- Allowance for price escalation. Published price indexes suffer from reporting-time lag and lack of sensitivity.
- Possibility of devaluation.

- Adverse climatic conditions; interruptions for monsoons, etc.
- Difficult maintenance conditions for construction equipment; need for spares inventory.
- Cost of delays caused by need to import equipment, including customs clearance.
- Customs duties for imported equipment.
- Need for a general contingency allowance.
- Need for a restricted reserve fund.

Few projects reach completion without meeting unforeseen difficulties, and the estimates must include sufficient allowances for such contingencies as changes in design and unexpected construction problems. In this regard Hackney has the following advice:

> The cost in lost time, confusion, mistakes, and inefficiency produced by changes in scope must be considered. A project in midcareer has tremendous momentum. It takes a substantial expenditure of money and time to change its direction. Sometimes the cost of disrupting the work to make changes will be found to outweigh the real but lesser benefits to be derived. In some cases it is best to complete the project as planned, making the necessary modifications at a later date and as a separate operation. 3/

Attention should also be given to the source of cost estimates. There is a natural optimism on the part of project planners that has to be discounted by others.

Bidding, Contracting and Procurement

This phase of project implementation includes: 1) sending out bid requests to qualified contractors or vendors; 2) analysis

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3/ John W. Hackney, op. cit., p. 16.

of bids; 3) comparison of the best bid with cost estimates; 4) contracting or placing orders with the lowest qualified bidders; 5) follow-up on contractor performance. There are well-established procedures and generally accepted conventions on bidding and contracting that should not be violated without very good cause. We will not go into these here, but will only point out certain mistakes to be particularly avoided by developing countries.

There is a rather common tendency to solicit bids from sources with which there is no real intention of placing the contract or order. This may be done, for example, to satisfy legal or political requirements for world-wide bidding, when in fact the development funds are a loan tied to a source of supply. Or it may result from simple curiousity about a variety of sources, or the desire to get additional cost data, although a preferred source is already in mind. Whatever the reason, this is poor practice and is self-defeating in the long run.

There is also a tendency in developing countries to accept the lowest bid without reference to the qualifications of the bidder to provide goods and services at the required time, and of the required amount and quality. At this point a consultant may be necessary, not only to assist in preparing the specifications and invitations to bid, but also to advise on the bidder to whom the contract should be awarded.

Hackney warns against these mistakes in the following words:

> Whether work is performed on a cost-plus, fixed-price, or any other basis, the owner must take precautions against getting the wrong contractor for the job at hand. This calls for pre-selection of contractors so that the low bidder will be acceptable. Inclusion of bidders on the list who will not be accepted by the owner, even if they submit the low bid, is indefensible.

> Contractors should not only be experienced in the type of work to be performed, but the size of the project should be of the order of magnitude to which they are geared. An organization which ordinarily handles very large projects may be ineffective in building small units unless it sets up a special part of its organization for this work. Similarly, a small contractor may get into difficulties if he attempts work which is too large for his organization at its current stage of development. 4/

Contracting methods vary from the turn-key contract, including start-up, on the one extreme, to contracting for delivery of plant only, on the other. The variations and combinations of approaches are almost limitless, and the appropriate method depends on the specific conditions, including: previous experience in the kind of project involved; availability of managerial and technical personnel; need for specialized equipment that a contractor may provide; time pressures; desire for training of local managers and technicians; technical complexities of the project; and political considerations.

John P. Lewis points out that a balance must be struck between meeting time schedules and having the project provide a meaningful learning experience for the developing country's personnel. He states:

> The best object lesson I know of on this can be drawn from the comparative experiences of the three Second-Plan public-sector steel mills, one built under Western German contracts at Rourkela in Orissa State, a second under a Soviet contract at Bhilai in Madya Pradesh, and the third by a consortium of British firms

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4/ John W. Hackney, op. cit., p. 268.

at Durgapur in the Damodar Valley region of West Bengal. These all are large steel-making units with initial designed capacities of about a million tons of ingot a year. Although they will produce different product lines by significantly different processes, . . . they are all designed to turn out satisfactory grades of steel with modern equipment and methods; and while each fell behind its original schedule . . . and each encountered some unexpected technical difficulties . . ., one gathers that all sooner or later will work.

Yet these three steel projects have received radically different ratings as to their success from most Indian and foreign observers. . . . The differences are not due to any inherent differences among the German, British and Russian nationalities, or between Soviet and Western economic systems. They were largely the predictable result of the widely different contractual arrangements into which the government of India had entered in the three cases.

At Rourkela, the first of the three projects to be undertaken, separate government-of-India contracts were signed with as many as thirtyfive individual German firms, and the entire burden of coordinating the project fell on the Indian management. . . . The end result of the Rourkela project will be a substantial success; but the distressingly awkward manner in which the work was organised probably can be blamed for some of the technical fumbles and certainly is responsible for unnecessary delays, unexpectedly high costs, and a certain amount of bad feeling.

At Durgapur, the last of the three projects to be started, contractual arrangements were carried to an opposite extreme; the government of India entered into a single contract with an *ad hoc* consortium of a dozen

British firms (which in turn did considerable subcontracting) for a finished, operable steel plant. Durgapur, in other words, was a turn-key job; full responsibility for coordinating all aspects of the construction lay with the consortium. The latter, evidently thoroughly mindful of the need for a unitary operation, was carrying forward its work efficiently. . . . But the Indians on the scene, compared with their colleagues at the other two sites, scarcely felt like participants. Lacking responsible involvement in the construction as such, they found that the latter gave them little preparation for the problems of operation.

What struck me most forcefully at Bhilai, having come directly from the other mills, . . . was the extraordinarily high morale of the Indian participants in the project. They were not only enormously proud of the relatively good record that the work at Bhilai had made; they were completely convinced that this was substantially their accomplishment. Sharing fully, as they saw it, in each step of the work, they had gained so much in-service training and experience during the project's planning and construction phases that they were thoroughly confident of their ability to move to an entirely Indian operation of the plant in very short order.

. . The procedural success of Bhilai was essentially the result of faithful execution of an astutely drawn contract — a single contract in which the Soviet government undertook to provide all required imports and foreign personnel in timely fashion, to provide training for Indian operators, and to supply all of the technical guidance necessary for building a plant of the specified capabilities; but, at the same time, the contract stipulated that all line decision making, as to design and construction as well as to subsequent operations, was to be the exclusive perogative of Indian project personnel . . . .

Superficially this was a curious contract in that each party obligated itself unilaterally to responsibilities that it could not in fact perform without the co-operation of the other; but precisely this, of course, was its particular strength: the contract forced detailed partnership, explicit bi-national co-operation and agreement at every stage of the project. It was this characteristic of the arrangement that, as widely reported, was mirrored at all levels of the project organization by the dual posting of Russian and Indian counterparts to most supervisory and technical positions. Each pair was required to work as partners, formally always with the Russian in the advisory, the Indian in the decision-making capacity, actually with the Indian assuming more and more of the joint initiative as the work proceeded. 5/

Construction and Start-up

There are two aspects of the construction and start-up phase that provide the source of most of the problems that occur during this last stage of project implementation. These are the general management and organization of construction, and the scheduling and control procedures.

The first essential condition for effective management of construction is unity of command in a single person, the project manager. He should be as close to the scene of action as possible, in the early stages at the engineering office and later at the construction site. Remote control of projects in the implementation stage does not work.

5/ Lewis, John P. Quiet Crisis in India. Washington D.C.: The Brookings Institution, Asia Publishing House, Bombay, 1962. pp. 295-298.

The shortage of managers capable of taking on full responsibility for project implementation is one of the main difficulties in the way of industrial development. It is sometimes compounded either by an unwillingness to employ foreigners in management or by the scarcity of suitable foreign personnel. There are various contracting and consulting arrangements for getting around this shortage, and although most may appear costly on first sight, they usually pay for themselves in time savings and the avoidance of costly mistakes.

The following account from Korea tells how a capable contracting firm, in spite of a series of staggering problems, managed to bring its project to timely completion through skilful project management.

> In April, Korea's Ministry of Commerce and Industry commissioned Universal Oil Products Company to conduct a preliminary engineering study for the proposed refinery. This study was completed in July, and negotiations began to select a firm to build the refinery.
>
> A corporation, with worldwide experience in engineering and construction of grass-roots refineries such as the one planned near Ulsan, guaranteed completion of the project within 16 months, and on October 17 won the contract for the project.
>
> The firm's overseas experience enabled it to foresee most problems associated with projects in other countries, but it faced additional obstacles unique to this Korean job-site; roads leading to it were poor; no communications network was available; lumber was practically non-existent; and sand and rock sources had to be developed.
>
> In addition, the contractor had to provide power for construction, establish security and fire protection services, furnish housing for personnel — in effect, make the site self-sufficient. Recruiting and training a native

work-force (which eventually numbered nearly 1,200) was another responsibility of the contracting company.

After establishing a liaison in Seoul, word was sent immediately to the contractor's home office, where engineering work began within 10 days and procurement of equipment began within a month.

Arrival of the general superintendent at the job-site in December helped in planning site preparation. Engineering and procurement, meanwhile, continued on schedule in the home office. By mid-February, construction equipment was on hand, temporary buildings had been constructed and the first supervisors had arrived to help organize the many construction activities and train workers.

Problems in site preparation caused the company to miss its intended start-up date of March 1 by nearly two weeks, and construction did not begin until March 12.

Korea's rainy climate, taken into consideration during original scheduling, surprised . . . and Koreans alike. Still striving to regain the two lost weeks, the workers encountered more delays when unusually heavy spring rains — the heaviest in Korean history — fell on the job-site in April and continued through May. The rains not only hampered all construction activity, but actually caused a cessation of work on several occasions.

For example, four inches of rain fell during a 10-hour period on April 18, completely flooding the project, burying materials under mud and causing excavations to cave in. By the end of May, the company was 30 days behind schedule.

In June, still a month behind, 13 inches of rain fell over a five-day period and the project was completely flooded again. Good working weather did not arrive until August, though the industrious Koreans — willing to work and capable of working in adverse weather conditions — had helped the company regain some of the lost time during July.

By September, the peak work-force of craftsmen was at work on the refinery. Aiding this effort were a minimum of design changes, cooperative vendors who supplied equipment on time and a lack of major shipping delays.

Shipping of equipment across national borders, often a major obstacle in construction progress of overseas projects, was expedited through an agreement with the Korean government for passing construction materials directly through customs unopened. This was the first time Korea worked out such an arrangement with a private firm.

Meanwhile, the urgency of completing the task had been relayed to the workers and to the sub-contractors responsible for offshore facilities, tankage and pipelines. Their response and a lack of major delays contributed to the amazing speed with which the job continued. Near the end of October, work was nearly 85 per cent complete.

On Dec. 21 — 58 days earlier than the contract called for — the contractor placed control of the refinery in the hands of Korea Oil Corporation. 6/

Many construction projects fall behind because of inadequate scheduling and control procedures. Progress reporting from projects under construction is frequently inadequate. A typical procedure is a report in two parts, one a narrative section describing physical progress, frequently done in general terms and sometimes without reference to specific targets, and the other an expenditure-to-date section that shows

6/ Russler, Walter L. "An Economic Renaissance Occurs in Korea", Korean Report, Vol. IV, No. 3, April-June 1964.

how fast the project is managing to spend money, without reference to the efficiency or economic timing of that expenditure. Although planning charts of the bar type, showing the sequence of activities to be accomplished by given future dates, are frequently prepared in the planning stage, they are far less frequently employed as control charts in the construction phase. In a later part of this paper presenting suggestions for improved practice, the network scheduling system is recommended and described. The system is not new; it is widely used elsewhere and has become the prevalent scheduling and control system for the construction industry in the developed countries.

Start-up problems are somewhat different from those of construction and require special consideration. Most important is to have the right people on hand in the right numbers. One way to train the key technical, production and maintenance staff is to have them work for a time in an operating plant of the same kind. There should be a start-up manager on hand, apart from the project manager and the future works manager. As a specialist in the start-up phase, who has been through it repeatedly before, he will be prepared to react quickly and correctly in the event of trouble.

The start-up of a plant using secondhand equipment and machinery is particularly chancey and difficult. There are obvious circumstances under which the purchase of secondhand equipment is a good idea. When, for example, the technology in a given field has made great advances, it is possible that the displaced machinery can be put to profitable use in a developing country. An advantage in the purchase of used machinery is that it can be delivered more quickly than new machinery. Most manufacturers require from six months to two years to supply new machines, whereas used machines can usually be acquired immediately and installed quickly. Used machinery generally costs from one-quarter to one-third as much as new machinery of most recent design. Used machinery, however, is no bargain if it does not produce satisfactorily. Unless the product it produces is competitive in quality with other available product, the machinery is a poor investment.

When secondhand plant and machinery is to be used in an industrial project, certain precautions can be taken to prevent difficulties and delays occurring at the time of installation and start-up. As a general rule it is well for the buyer not to try to go it alone. There are three courses of action he can follow in seeking help. First, he can engage managers or consultants from abroad who will help him buy and install the secondhand machinery. A second method, and perhaps the safest of all, is through a joint business venture with the firm that is selling the second-hand equipment. This has been done on many occasions with considerable success. If neither of these alternatives is available, the buyer should engage an independent expert to examine the machinery he is considering buying. There are some companies that do this as a regular service.

No matter how the buyer attempts to protect himself against the purchase of unusable machinery, there are still dangers in the practice. Machinery must be tested under power and in operating conditions to make sure that it works properly. Merely the sight of a machine that appears to be in good condition is not adequate to understand it. The purchaser must also find out if the machine has all of the necessary attachments and accessories. Many machines sold "as is" are not useful unless the accessories can be found. There is also the problem of dismantling, packing, shipping, and re-assembling the equipment. Many pieces of equipment may operate in their old location, but never can be put together to operate successfully elsewhere. For these reasons it is well for the buyer to have some recourse or control over the situation until the machines have been put into production.

THE COST OF DELAYS

Although much has been said and written about the costs of delays in project implementation — the tied-up capital, the loss of earning opportunity and the immobilizing of scarce foreign exchange — little data exists on the magnitude of these costs, or their relation to various rates of time discount. A study 7/ recently completed in India provides the first organized information on this subject. The study points out that developing countries should use high rates of time discount in calculating the present value of committed funds.

> The low rate of substitution of future for present consumption . . ., the relative over-supply of labour and also the political determination to accelerate economic growth by rapid increases in the level of investment, all tend to determine high rates of time discount. These high rates emphasize the importance of obtaining maximal returns from investments, and put a heavy weight on the returns obtainable during the first few years of project life. Yet, in . . . many . . . developing countries, one encounters large sums tied up in projects with extended gestation periods, widespread and considerable lags in project completion, and substantial under-utilisation of both new and existing facilities. These represent a large loss to the nation in potential income and potential savings for re-investment. 8/

7/ This section draws heavily upon the doctoral dissertation of Robert C. Repetto, Temporal Elements of Indian Development, Department of Economics, Harvard University, Cambridge, Mass., October 1967.

8/ IBID, p. II-1.

Table I gives the length of time from approval in principle to full production for 41 public-sector capital projects in India. The data are necessarily crude; in some cases they are based on estimates. They serve, however, to provide a sense of dimension. The public sector is used for this illustration, not because the private sector has necessarily fared any better in keeping its projects to schedule, but because the accounting procedures of the public sector provide open information on this subject. Also, it must be emphasized, that the Indian case is used not because it represents either poor practice or good practice, but because it is the only case available.

The average lag from initially scheduled production start for these 41 projects is about $1\frac{1}{4}$ years. The total average time to go from the first project approval to full capacity operations ranged from $7\frac{1}{4}$ years for thermal power projects to 10 $^3/_4$ years for nitrogenous fertilizer plants. In many cases the funds, both foreign and domestic, for these projects were committed, and immobilized, at the time of project approval. The costs of these under-utilised resources is a major source of inadequate returns to investment.

Table 2 [9] presents the results of discounted cash flow calculations which show the effects of more rapid project completion and attainment of full capacity production on the net worth of individual projects. Two sets of alternative assumptions about financing methods are made:

Assumption No.1: Investment costs coincide in time with investment outlays. The effect of this pay-as-you-go assumption is to minimise the cost of lags in the construction period, since such lags defer both benefits and costs. This assumption is usually invalid, for at least the foreign capital

9/ For the calculations leading to Table 2 see the Appendix to this paper.

TABLE I

LENGTH OF PERIOD, IN YEARS, FROM APPROVAL TO FULL OPERATION — FORTY-ONE CAPITAL PROJECTS IN INDIA 10/

[illegible]	Approval in Principle to Receipt of Detailed Project Report		Detailed Project Report to Final Government Approval		Final Approval to Start of Construction		Construction Start to Commercial Production Start		Lag from Initially Scheduled Production Start		Commercial Production Start to Full Capacity Operations		Total Average Time
1. Five Nitrogenous Fertilizer Projects	2	(3)	¼	(3)	2¼	(5)	3 3/4	(5)	2½	(5)	2½	(2)	10 3/4
2. Four Refinery Projects	- - - -		- - - -		- - - -		2 3/4	(3)	1	(4)	1	(2)	- - - -
3. Ten Thermal Power Projects	1½	(2)	1	(8)	3/4	(8)	3¼	(10)	1¼	(10)	3/4	(6)	7¼
4. Twelve Engineering and Machinery Projects	1¼	(8)	½	(8)	3/4	(9)	2	(11)	1	(6)	5¼	(12)*	9 3/4
5. Five Coal Washeries**	2	(4)	1½	(4)@	- - - -		2 3/4	(5)#	1	(4)	4	(2)	10½
6. Five Steel Projects	1	(5)	3/4	(5)	½	(4)	2½	(4)#	3/4	(5)§	3	(3)§	7 3/4

The number of projects included in the average is given in parentheses.

Sources: Data were collected from various annual reports on the working of public sector enterprises, and Planning Commission documents.

* mostly estimated.
** including two expansions.
@ NIT to major contract award.
\# contract award to production start.
§ refers to finished steel.

10/ Repetto, R.C. op cit, p. II-3.

TABLE 2

Reduction in Net Worth as % of Capital Employed

(At a capital: Output Ratio of 2:1)

	7% Discount Rate			15% Discount Rate		
Assumption No.1	Lag in Project Completion					
	1 year	2 year	3 year	1 year	2 year	3 year
	1.5%	3%	4.5%	3%	6%	9%
	Delay in Reaching Full Capacity					
	1 year	2 year	3 year	1 year	2 year	3 year
	7%	12%	16%	10%	17%	20%
Assumption No.2	Lag in Project Completion					
	1 year	2 year	3 year	1 year	2 year	3 year
	4%	7%	10%	8%	13%	18%
	Delay in Reaching Full Capacity					
	1 year	2 year	3 year	1 year	2 year	3 year
	10%	16%	22%	12%	19%	24%

component of investment, which is typically allocated before the project is undertaken, and is thereafter unavailable for other projects.

Assumption No.2: One-half the capital is committed at the time of project approval; the rest is pay-as-you-go.

The production life of all projects is assumed to be fifteen years, with no subsequent scrap value. The start of production is assumed to occur after 75% of the total investment is disbursed, a conservative assumption. Discount rates of 7% and 15% have been used.

The results, as shown in Table 2, although roughly drawn and intended to be notional only, indicate that delays in reaching full capacity have a particularly strong impact on the net value of projects at both high and low rates of discount. Under assumption number 2 the cost of delay in reaching full capacity production is about the same for both discount rates, since the higher operating margins and higher discount rates tend to cancel each other out.

Table 2 shows, for example, that at a 15% discount rate, a one-year lag in project completion can reduce the net worth of an industrial project by about 8%, and a delay of one year in reaching full capacity can reduce the net worth of the same project by another 12%.

If one puts these figures together, it appears that the combined effect of more economical financing methods, accelerating completion by one year, and attaining full capacity one year earlier would save an amount equal to roughly 15%-17% of investment at a 7% discount rate, and about 22%-24% of investment at a 15% discount rate.

This comparison shows the great difference efficient management can make in the utilisation of scarce capital. This difference is at least of the same order of magnitude as differences in costs due to locational factors, economies of scale and labour productivity.

SOME SUGGESTIONS FOR AVOIDING PROBLEMS OF IMPLEMENTATION

As the previous sections of this paper have indicated, the best way to avoid problems and delays in the implementation phase of industrial projects is through meticulous project planning and continuous attention to the cost of time. Most of the kinds of problems itemized and discussed here are avoidable if anticipated. As developing countries gain repeated experience in project planning and implementation they learn to avoid these problems, and the quality of performance improves.

Perhaps the greatest single opportunity for improved practice in implementing industrial projects is in the area of project scheduling and control methods. Powerful techniques are available that have not been broadly applied in developing countries. Among these is "critical path scheduling".

Improved Scheduling and Control

Critical path scheduling is based on the concept of discovering, and paying particular attention to, the longest time-path through a network of activities. The system is not new; it is widely used elsewhere and has become the prevalent scheduling and control system for the construction industry in advanced countries. Although most users of the method employ computers in its use, this is not an essential aspect of the method. A paper-and-pencil adaptation can be worked out appropriate to the needs of developing countries.

The basis of critical path scheduling is the application of the concept of network analysis to the planning and control of time schedules. The concept of network analysis is similar to that used in communications and electronics. Planning a project as a network of activities allows the application of precise techniques to the problem of planning the time schedules and the cost schedule of the project. The planning of performance is the planning of the physical activities and sequence of operations necessary to achieve the project objectives. The planning of time schedules is the correlation of the performance plan to calendar dates in order to insure meeting deadlines.

The first step in the planning of operations begins with the definition of the project's objectives and its scope. The project is then analyzed into the activities required. The activities should be broken down into the smallest unit that has to be scheduled and controlled.

The important data needed are the activities, their estimated times, and some way of showing efficiently the sequence of activities required. The logical analysis required to draw up the lists of activities and to establish their sequence relationships provides in itself an advantage of the system. Exhibit 1 shows an example of the major activities required to build a house. This list is, of course, greatly simplified as compared to the list of activities which a building contractor would want to use; however, the simplified listings of activities is more appropriate for explanation here. The Exhibit 1 shows, in addition to the listing of activities, the sequence of activities required and an estimate of the normal time for completion of each activity in days. These sequences are imposed by the technological requirements of the activities. For example, one cannot pour the foundations before excavation.

From Exhibit 1 we can now prepare the arrow diagram or project graph shown in Exhibit 2. In this exhibit the circles represent activities and the arrows represent sequences of activities required to carry through the project. The rules for constructing the project graph are simple. Arrows indicate direction of flow, and activities connected by an arrow indicate that the second in the sequence must be preceded by the first. If it is possible to trace a circular path through the maze at any point, some mistake has been made in determining the precedence relationships or in preparing the diagram.

We could enumerate 22 unique paths from start to finish through the diagram. The shortest path requires 14 days by the sequence in a-b-c-r-v-w-x. The longest path through the system requires 34 days, through the activity sequence a-b-c-d-j-k-l-n-t-s-x. The latter is the critical path. It determines the over-all minimum project time and indicates which activities are critical in meeting this minimum time schedule. If the contractor attempts to complete the house in less than 34 days, it would be necessary for him somehow to shorten the time requirements for one or more of the activities along the critical path. It would be useless to shorten the time requirements for jobs not on the critical path.

Determining the critical path for a project graph as simple as the one for Exhibit 2 is neither difficult nor time consuming, since we need only to compare time requirements in the alternate branches to determine which path takes maximum time. For the complex projects for which critical path scheduling is designed, however, the critical path is not obvious, and it usually requires some calculation to discover it.

Although network analysis provides a highly systematized and logical method of planning, it does not relieve management of the responsibility for control. Network analysis does not provide automatic control or automatic planning. It does provide a highly efficient tool for planning and control.

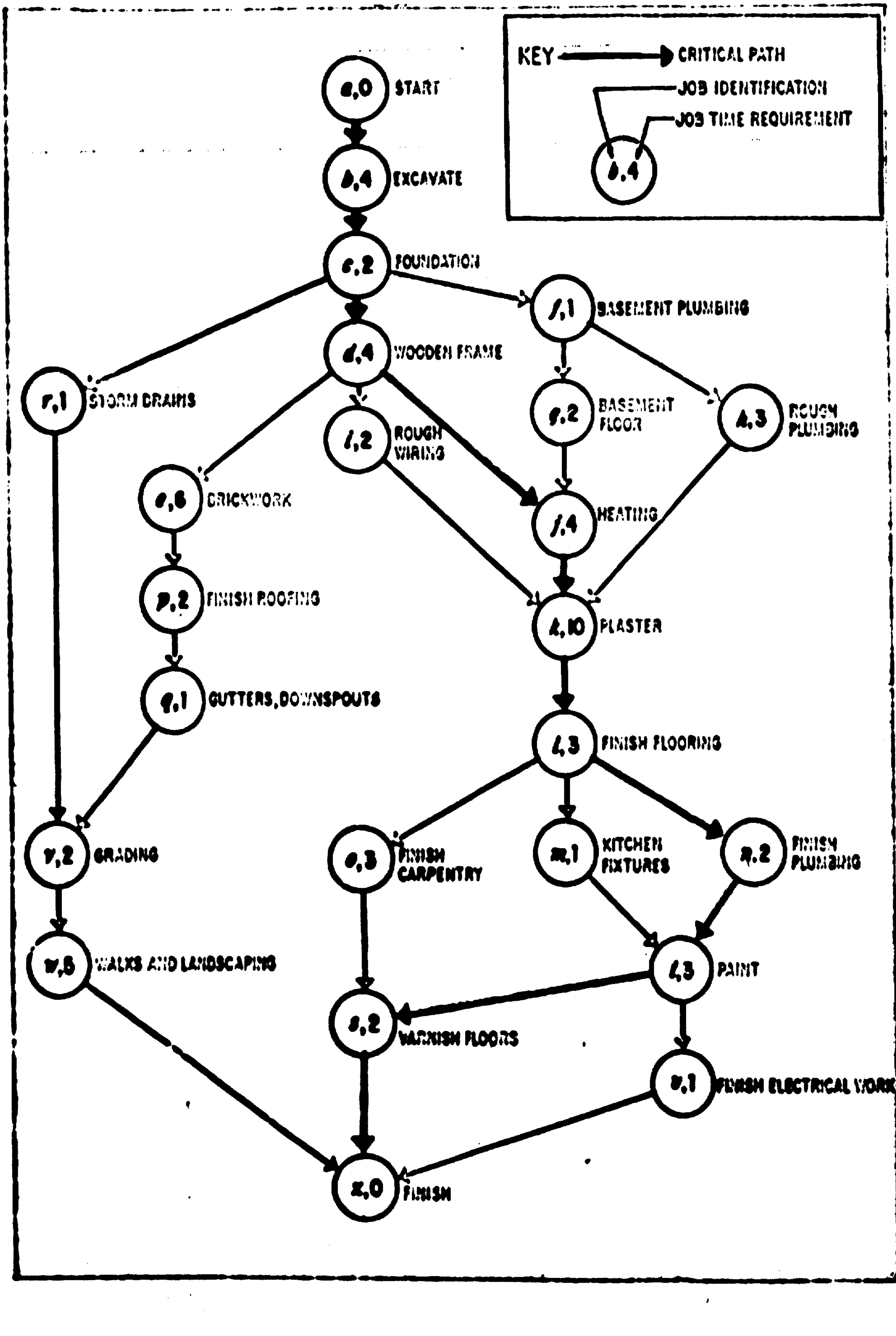
The first point where control has to be exercised by management is in the definition of the project objectives, and this should occur in the planning phase, before the list of the component activities of the project is drawn up. The list of activities should be agreed upon by all those involved in the particular project. The prevalent custom seems to be to delay approval of the list of activities until an arrow diagram has already been prepared, since the development of the arrow diagram itself helps to verify the list of activities.

Exhibit 1

Sequence and Time Requirements of Jobs in Building a House

Job No.	Description	Immediate Predecessors	Normal time (Days)
a	Start		0
b	Excavate and pour footers	a	4
c	Pour concrete foundation	b	2
d	Erect wooden frame including rough roof	c	4
e	Lay brickwork	d	6
f	Install basement drains and plumbing	c	1
g	Pour basement floor	f	2
h	Install rough plumbing	f	3
i	Install rough wiring	d	2
j	Install heating and ventilating	d,g	4
k	Fasten plaster board and plaster (including drying)	i,j,h	10
l	Lay finish flooring	k	3
m	Install kitchen fixtures	l	1
n	Install finish plumbing	l	2
o	Finish carpentry	l	3
p	Finish roofing and flashing	e	2
q	Fasten gutters and downspouts	p	1
r	Lay storm drains for rain water	c	1
s	Sand and varnish flooring	o,t	2
t	Paint	m,n	3
u	Finish electrical work	t	1
v	Finish grading	q,r	2
w	Pour walks and complete landscaping	v	5
x	Finish	s,u,w	0

EXHIBIT 2 PROJECT GRAPH



Approval of the arrow diagram is probably the key control function in the planning phase. This approval really means approval of a detailed plan of action. If modifications or changes are later introduced, they can always be related to the original diagram.

A series of reports may be generated during the course of the project to control performance. With the basic data provided in the schedule (earliest and latest start and finish times, and critical path), many variations of these data may be obtained by sorting and tabulation. The strategic factor in controlling performance is maintaining the schedule. An information system can be set up so that revised schedules produced periodically will reflect the latest revisions in time estimates and the latest actual times for activities completed. This type of updating procedure fulfills the needs of project management. In addition, the head office should be told exactly how each revised schedule departs from the original plan. Especially at the end of the project a comparison of the original and the final schedule actually accomplished is desirable in order to determine what should be modified in the next project so that mistakes are not repeated.

Simplified Engineering and Design

This section suggests two engineering approaches to faster project implementation. They are not meant to be taken too seriously in themselves, but are presented as ideas of the sort of thing to which more attention should perhaps be given. The first has to do with standardisation of plant design.

Once the process to be employed has been adapted to local conditions, the next task is the engineering design of the plant facilities. Individual plant design is an expensive procedure, amounting to an estimated 15% of the total project cost, and it provides unlimited opportunities for mistakes, delays and over-runs on construction costs. Detailed engineering and construction drawings, specifications, and lists of equipment and materials needed, all phased in the proper order for delivery on the site, are required for the processing equipment, the foundations and building, and any auxiliary services needed.

Normally this work is handled by a consulting engineering firm, who must have experience and particular competence in the industrial process, and thorough integrity in dealing with the numerous suppliers of machinery and construction services. Well and properly done, this process results in satisfactory construction and operation, but it is difficult and expensive to perform and the number of qualified firms is limited. The alternative is standardized plant design. The advantage of standardization is that, when once constructed and operated at one location the same plans and procedures, corrected and improved where necessary, can be employed at known costs and known results in other areas. These known costs and results can be transposed to make the planning of other projects of the same type immeasurably easier and the implementation much more certain. The difficulties with standardized plant design are with the site requirements and variations requested in production volume, but floating concrete slab foundations are generally usable on all sites, regardless of soil conditions, and modular design can usually offer definite steps in planned production output.

One company, for example, has designed six sizes of standard package petroleum refineries specifically for sale to less developed regions. These are self-sufficient units, built to generate their own power and supply their own steam and water treatment facilities, so they may operate at sites removed from centres of industry. The company provides a detailed proposal on operation, with guaranteed volume and quality specifications for the output, on-site construction, and oven supervision in operation and maintenance, if desired. This very complete "turn-key" concept removes the burdens of organisational and administrative responsibilities usually borne by the purchaser in multiple-contract bidding, and permits the contractor to accept wide responsibility and penalty clauses in regard to performance, without charging a wide margin for uncertainties. The cost and time savings to the purchaser of standardized design can thus be very substantial.

Another engineering approach to faster project implementation is prefabrication. As with standardized design, this idea of prefabrication is meant to be notional and suggestive only, to indicate the kind of things that might be considered.

The construction of process facilities on-site in the less developed countries is an awkward and time consuming process. Construction material may well be of uncertain quality, of diverse standards, and difficult to obtain on schedule, or difficult to obtain at all. Material problems, willing but unskilled labour, unusual climatic conditions and difficult transport in a remote area, combine to delay projects and over-run costs.

As local contractors may be unqualified for industrial projects, which require a considerable measure of experience and managerial organization, the use of international construction companies has become common. These firms accept the responsibility, often with penalty clauses, for performance to standard specifications and schedules; they provide the material, the supervisory personnel, and the construction machinery required to build the plant on the site, but even with experience and equipment the work is demanding.

An alternative to on-site construction is the use of prefabricated plants. These are compact industrial processes that can be built complete, at considerably reduced cost, in an industrialised nation, with skilled labour and fabricating, machining and handling equipment available, and under experienced engineers and cost and quality supervision. Prefabrication is a new industrial technique. It may be either in the form of a completely self-contained unit that is shipped disassembled, but requires no skilled labour for assembly, or a component package of parts ready for assembly with some skilled labour, but no local material.

An example of the prefabrication technique is seen in the recent installation of a petroleum refinery at Port Brega, Libya. This refinery, with a capacity of 8,000 barrels per day, which is adequate for Libyan requirements of kerosene, gasoline, diesel and fuel oil, was built with modular design on a concrete barge at the shipyards at Antwerp, and then towed 3,000 miles to the site. The barge was then set in a dredget inlet, with the concrete base forming the permanent foundation and linked to a tank farm on the shore. Delivered on time, it was ready for operation 3 days later. The project was considered so successful that a number of other standard and prefabricated refineries are planned, and a barge-mounted power station, with two turbine generators of 12,500 kw capacity, has been ordered for Port Brega, to be installed next to the refinery.

Industrial Estates and Prepared Lands

Another way in which developing countries can avoid problems in the implementation of industrial projects, especially medium-sized and smaller projects, is by providing them with industrial estates or prepared lands.

An industrial estate is a tract of land which is subdivided and developed for the use of industry. Provisions are normally made for streets and roads, transportation facilities and the necessary utilities. In some industrial estates factory buildings are erected in advance of sale or lease to the occupants. In other industrial estates only the land is subdivided and prepared for industry.

Although all sizes of enterprise benefit from locating in industrial estates, the benefits appear to be greatest and most obvious for small- and medium-scale factories. Larger industrial enterprises often have the financial and managerial resources to develop the property themselves.

Industrial estates assist in many ways to prevent or overcome the problems of project implementation. First, they save the time and cost normally needed in the selection of a sight and the purchase of land. Problems of industrial zoning and local taxes are completely eliminated. Progress need not be delayed while the basic utilities are provided. Water, electricity and sewage disposal frequently present a major problem in the preparation of a plant site in developing countries. Many estates provide training services to prepare the work force for employment before the factory is completed. This eliminates the necessity of in-plant training, which frequently slows down the rate at which the factory is brought into full production. Where the estate provides both land and the buildings on a lease basis, the financing of industries is considerably easier.

The development of an industrial estate is in itself, of course, the implementation of an industrial project, and all that has been said above about the importance of time applies equally well to the industrial estate. The most important cost element is speed in constructing the project and having it fully occupied by industrial plants. The sooner development funds are recovered the more quickly they can be used for other things, and, conversely, slow development of the estate retards the income stream from the investment and hurts the financial success of the project.

A CASE STUDY: THE FERTILIZER CORPORATION OF INDIA 11/

To illuminate some of the problems involved in the implementing of industrial projects in developing countries, and to show how some of them may be overcome with time, the Fertiliser Corporation of India was chosen as a significant case study. FCI is a large, multi-plant, public-sector firm presently contributing more than half the total output of the Indian nitrogenous fertilizer industry. It, or its organisational predecessors, have during the past twenty years participated in eight major new projects, including four now (1968) in various stages of implementation, as well as several substantial expansions. The general directive governing FCI's current expansion plans is to be prepared to undertake two new projects during the next five years, in addition to those now under way. In some of their past projects, they have experienced serious difficulties and long delays in the completion of work, so their growing capacity to carry out their heavy responsibilities is a matter of considerable interest.

Problems Encountered

The problems the Fertiliser Corporation of India has faced are, in fact, very much like those encountered in other Indian industries both public and — to an extent — private. A general sketch of the most critical problem areas follows:

1. Projects, especially in the public sector, have been consistently delayed by the prolonged process of decision making regarding essential features of the undertaking: size, location, process, output mix, mode of implementation and financing, etc. Often, even in priority projects, this process

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11/ This is a condensed version of a case prepared by Robert C. Repetto, and presented in his doctoral thesis. op. cit. pp. III-4 to III-25. (Used with permission of the author).

has taken longer than actual implementation. The reasons are many. One is the instability of the economic environment — including, of course, conditions surrounding foreign credits — and the uncertainty regarding the state of the market after three to six years, when the project would come on stream. Some of this is inherent in an economy undergoing rapid structural change. Some of it is due to tight resource constraints managed by rigid direct controls. In fact, long gestation periods increase the forecasting problem, to which the conscientious reaction is further study to refine the data available for decision, which further lengthens the gestation period. In certain projects in the past, this cycle of re-definition and re-study threatened to continue indefinitely.

Another problem has been the diffusion of responsibility for project planning and decision, and the extensive provisions for review which have prevailed. This has been largely an attempt to ensure conformity of the individual project with over-all financial and sectoral plans and policies, in the context of rapid structural change. It has also been, in the public sector, a reflection of some lack of confidence in the capabilities of management in the enterprises to plan and define new projects, when, in fact, management in some enterprises lacked the experience and staff to do so. It has been, in the private sector, a reflection of Government's lack of confidence in market signals and the price mechanism, when, in fact, relative prices have been both volatile and distorted. The result, however, has been a time-consuming process of deliberation, clarification, revision and review by a multitude of agencies.

2. A related problem has been frequent revision of project plans after execution has begun, entailing considerable loss of time. Sometimes, new conditions or information have arisen to enforce changes in plans. Sometimes, however, inadequacies in planning have been at fault. These have not only delayed decision-making, as sketchy planning work is

clarified and amplified in the review process, but have also led to regrettable and costly changes later on. Also, inadequate attention to the cost of time has sometimes permitted changes in scope where not absolutely necessary, in order to effect marginal cost economies or to meet additional demands, at a price in lost time which would be found to outweigh the real benefits to be gained.

3. A third problem has been delay in procurement, encompassing land acquisition, contract award and approval, import licensing and foreign exchange release, and procurement of scarce domestic materials. Land acquisition, especially if many owners or tenants occupy the desired site, has frequently been a protracted process of negotiation of adequate compensation, appeal through the courts, agitation and local political skirmishing, and problems of re-settling the "outsees". These problems touch complex legal and social issues.

Numerous difficulties have similarly hampered the lotting of contracts: accumulation of data needed for the preparation of tender invitations, which often rest on submissions by design consultants or equipment suppliers; evaluation of bids with wide divergence among bidders in scope, design, foreign exchange component, and so on; sometimes problems of finding qualified bidders within the country for domestic services, or in the country of origin for country-tied aid-financed projects; problems of negotiation when, for one reason or another, there is less than adequate competition among bidders; problems of fixing responsibility narrowly enough to avoid time-consuming review or committee deliberations. The result of all these problems has been that delays, sometimes as long as a year or more, have not infrequently occurred in finalising key contracts, retarding progress on the whole project.

Procurement problems associated with import licensing have so many ramifications and strike so deeply that the subject requires a book to itself. Basically, however, the extreme balance of payments constraint has engendered a system of import control involving close scrutiny of proposed foreign exchange expenditure for essentiality and domestic availability of equivalent items, a complicated problem of matching import demands against various tied foreign exchange sources, and heavy competition and long queues for extremely limited amounts of free foreign exchange. Similarly, shortages and rationing of domestic materials in short supply at one time or another, including iron and steel, cement, coal and coke, non-ferrous metals, and rail transport, have interfered with timely procurement.

4. A fourth problem has been inadequate control over schedule in both pre-construction and construction phases of new projects. In relatively new industries, the development of realistic operating schedules has been hampered by the lack of sufficient data on the resources and time required under Indian conditions to complete various project activities. The lack of detailed and meticulous project planning at an early stage has also been at times a handicap to schedule development.

These scheduling deficiencies have contributed to an excessively loose control over contractor performance: i.e. control not based on well-defined contractual responsibilities to meet definite and detailed schedule commitments. Frequently, contracting firms are deficient in equipment, technical and supervisory personnel, highly skilled labour and trained management. Therefore, successful project execution often requires a more intensive supervision of contractor performance, and adoption by project management of many planning responsibilities that in other countries might be delegated in large part to the contractor.

5. A fifth problem has been lack of synchronisation in inter-dependent projects, leading to delays in the availability of inputs, or delays in the emergence of markets. When slippages in infra-structure, like power or transport, have occurred, these have been particularly damaging, since compensating imports are impossible; but, even for other

inputs, foreign exchange constraints have sometimes delayed or prohibited compensating imports as well. Slippages in forward-linked projects have delayed full utilization of new capacity, since alternative uses or export markets can rarely be found within a short period. This problem returns full circle to the difficulties involved in "consistent" planning of inter-related projects in a rapidly changing environment without full control of all schedules.

Solutions Developed

With this introduction, it is now possible to explore specific adaptations by which the Fertilizer Corporation of India has countered such problems in the field of project management. It must be emphasized at the outset that the process of learning and adaptation is by no means complete. On the contrary, several rather significant examples are given below of economies and benefits yet to be realized.

One specific adaptation lies in the area of industrial organization, and concerns the formation of the FCI itself. This step was a conscious attempt to capture infant industry economies by internalizing them. The Government of India has by-and-large favoured the unification of projects into large multi-plant organizations rather than the proliferation of separate undertakings.

This policy has yielded demonstrable benefits. Under it, for example, the FCI has generated a fully staffed and equipped planning, design and research division with specialized teams for process design, engineering, fundamental research, and also for techno-economic studies relevant to the industry in general, or to particular projects. As this division has grown, it has gradually substituted local for imported services in project planning, design and engineering and project management. In contrast to the first fertilizer project, which was implemented under two main contracts, one with a firm of consulting engineers, the other with a "constructor" who selected contractors and coordinated and supervised their work, the owner's responsibilities in later projects included management of civil works and erection, as well as complete responsibility for most ancillary facilities. In its most recent projects, FCI is acting practically as its own turn-key contractor. Apart from certain process know-how and design services provided by the foreign technical collaborator, responsibility for all phases of the project lies directly with FCI. This has important implications for design, procurement, contracting and control of schedule. What is important to recognize is that this development could not have taken place without the pooling of available talent and know-how in a single organization, and a sufficient scale of operations and expansions to justify such an establishment. These, in turn, stem directly from the decision to integrate public sector fertilizer units under the FCI.

The implications of the import substitution in project services which has accompanied the growth of FCI's Planning & Development Division (P&D) shed light on the benefits of the learning experience. First of all, with greater local engineering, it has been possible to seek more actively for ways to increase the Indian component of plant and equipment. FCI engineers have surveyed local fabrication capabilities, and actively collaborated with potential suppliers. In some instances, it has been possible to modify the specifications of materials, vessels, or equipment to bring them into consonance with suppliers' capabilities, with no repercussions on the overall process design. This is something foreign engineers could do as well, but there is little incentive for them to undertake the extra effort, or to depart from their conventional engineering standards and specifications; and, it is difficult to force them to do so, especially if performance guarantees are demanded. One indication of the extent to which Indian efforts have been successful is the increase in the local content of plant and equipment from

10%-20% in the foreign-engineered plants to 40%-50% in the Indian-engineered plants.

Secondly, local design has facilitated modifications to bring international designs into closer accord with Indian conditions. In India, for example, maintenance tends to be a relatively more serious problem, in part because of the lack of experience of operating personnel, in part because of the time-consuming procedures for obtaining replacements, mostly from abroad out of free foreign exchange. Yet, the increasing sophistication and competition of the chemical engineering business has led to plant designs ever more closely restricted to rated capacity, with less built-in spare capacity, so that it has become more difficult to attain and sustain this rated level of output. Indian engineers have tended to be on the conservative side, in building in a margin of safety and avoiding unproven designs. This may be a more economical course under Indian conditions.

Another advantage of the trend toward wholly indigenous engineering is its impact on schedule. In the past, FCI has experienced considerable difficulty in obtaining a timely flow of data and drawings, and this has led to interruptions in the orderly progress of contracting, engineering, fabrication, civil works and erection. When, in addition to the owner, there are separate contractors — many of them foreign — for civil works, civil engineering, plant design and engineering, equipment supply, with numerous sub-contractors for fabrication, the lines of communication tend to become excessively complicated. Effective coordination is difficult. Moreover, the schedule most to the advantage of the owner may imply a sequence of work which does not minimise cost to some or any of the contractors. Then, real problems arise in holding contractors to schedule commitments. A unified engineering responsibility, like that evolved by the FCI acting like its own turn-key contractor, ameliorates many of these problems. Communications are improved and conflicts of interest are reduced. As a result, time lost through interruption in the even flow of work has been reduced.

A more significant benefit that has resulted from import substitution in design and engineering is the degree of standardization it has permitted. Standardization of plant and equipment design in the past has been difficult to achieve, because financing has linked procurement to particular countries and because foreign engineering firms — with their own engineering practices and standards, and holding only certain licenses for process know-how — have been entrusted with the job. Recently, however, the interaction of local design and greater reliance on foreign suppliers' credits has permitted FCI to plan at least four major projects which will be very similar.

One result of standardization will be a reduction of difficulties and delay in contracting. Technical information will be available at a very early date to permit the contracting process to begin. Of greater significance is the prospect of significant reductions in project time schedules, as well as costs. Design and engineering time on subsequent plants should be reduced by several months. Quoted delivery times for critical equipment should be shortened by a few months, not only because of the learning curve in fabricators' shops but also because of the reduction in contingency margins usually included in the suppliers' quotations when substantial penalties for late delivery are imposed in contract terms. Erection and commissioning time, and the time required to stabilize production at high levels, may also be reduced, but this will depend largely on the extent to which key personnel experienced in previous plants of the same design are included in the erection and commissioning teams.

In addition to these time savings, standardization will lead to cost savings of perhaps 5% of total capital costs in subsequent projects, due to 40% to 50% reduction in design and engineering costs; reduced payments to the foreign collaborators for checking of drawings, supervision of erection and use of licensed know-how; reduced spares and inventories; and reduced indigenous procurement costs due to economies of scale and reduced wastage of materials.

Another critical area in which the benefits of experience have been apparent is that of project planning. Not only in the FCI, nor only in the fertilizer industry, nor only in India, deficiencies in investment planning have been a serious source of cost and schedule overruns. It is evident, however, from an examination of the project plans on which decisions and actions have been taken that the FCI has made considerable progress in generating thorough and competent project studies. For early projects, the basic techno-economic studies which usually underlay project approval were carried out by foreign consultants, ad hoc committees of Indian experts, or by the engineering departments of operating divisions. Examination of these studies for earlier projects reveals serious limitations on the quality of relevant data available at the time of decision, the adequacy of economic analysis, and the amount of detailed technical and administrative planning accomplished at an early stage, in comparison to the plans for later projects. More recently, a single department within the P&D Division has been formed to make continuing studies of demand, location and design of new units, of raw materials and equipment availabilities, as well as techno-economic studies for particular projects under consideration. This has obvious advantages: the accumulation of expertise and experience; the possibility of engaging in long-term and continuing studies of the basic economic and technical factors affecting the industry; the creation of a central repository for relevant price, cost and process information. Moreover, it fixes responsibility for the execution of these functions in a single agency, operating under policy guidelines from above, instead of having responsibility diffused throughout the organisation and various organs of government.

An earlier section of this paper emphasized the important role the length of the gestation period has in determining project costs and profitability. Consequently, a most significant area in which experience has led to economies is that of project scheduling, reporting and control. Since so many concurrent and interrelated activities take place, executed by so many agencies, in a major investment project, the detailed analysis and scheduling of work is fundamental to fix the responsibilities of all parties and to direct efforts and resources into a consistent pattern. In earlier FCI projects, schedule slippage was a major problem, and led to unduly long periods of time required for completion: more than five years on the average. Obviously, this imposed a considerable cost on the economy, given the amount of capital locked into fertilizer projects and the high price of fertilizer on international markets. With FCI's latest project, however, an attempt has been made from the very outset to make full use of modern techniques of scheduling and control. Both the Project Coordination Department, specially formed in the P&D Division for this purpose, and the Project Planning Office at the site, have taken vigorous action to install usable systems based on network analysis, encompassing the derivation of adequate contractual milestones, procurement planning, work scheduling, management reporting, cost accounting, data storage and analysis. This system has helped to avoid any major hitches in the progress of the latest project since work has begun, and will undoubtedly be of even greater service in the future, as it is perfected and extended.

In the area of contracting policy and procedures, experience has led the FCI toward solutions of several problems; how to avoid protracted discussion, clarification, re-tender, negotiation and review in concluding important contracts; how to ensure the selection of contractors able and equipped to perform satisfactorily; and, how to gain and maintain effective control of contractor performance over the course of work.

In the past, the period of contract award has been unduly extended for a number of reasons. Imprecise, overly general tender specifications or specifications which had subsequently to be revised often led to numerous requests for clarification of bids, difficulties in comparing bids submitted on widely different bases, protracted negotiations, or the solicitation of fresh bids. Over time, however, the period required for the preparation and evaluation of tenders has tended to decline, due to FCI's increasing experience in design and engineering. In the most recent projects, process, equipment and the scope of supply have been more closely specified in tender documents and removed from the area of negotiation, so that FCI has found itself less often faced with widely disparate bids.

Another time-saving adaptation has been to reduce the number of people involved in bid evaluation. Evidently, during earlier periods, the tendency was to assemble high-powered committees for important contract decisions, including not only senior people from FCI divisions but also outside experts. This undoubtedly engaged the most experienced judgements available, lent weight to the recommendations, and fostered a broad collective responsibility for decisions. Unfortunately, however, the most senior men tended naturally to be those with the most numerous and pressing commitments elsewhere, so that it was often a task of considerable magnitude to convene these people quickly enough to reach a speedy decision. This tendency seems now to have been reversed, with the P&D Division and the site organisation sharing the major responsibilities for contracting. Similarly, a good deal of time was consumed in Government in the review and approval of contracts. Recently, an attempt has been made to shorten this process by forming a single committee comprising officers of all concerned agencies to consider such matters at one sitting.

Procedures also have evolved to ensure the selection of qualified contractors. To give adequate weight to competence, quality and reliability in the evaluation of bids in public-sector enterprises is difficult, because of a well-developed system of financial post-audit and a well-developed fear of venality and favouritism. Thus, a low bid, even an unrealistically low bid, cannot be rejected without elaborate justification, and even then the door is open to complaints from dissatisfied bidders about favouritism, failure to encourage new entrants into the field, and so on. In recent projects, FCI has used a screening procedure, whereby prospective bidders are invited to submit particulars of their experience and qualifications, and tenders are invited only from those judged, with concurrence at high levels, to be eligible. For fabrication and equipment supply contracts, FCI has for reference a thorough survey of capacities and capabilities performed at periodic intervals, so that tenders can be invited only from qualified manufacturers.

Other changes in contracting policy have increased FCI's ability to control contractor performance while work is in progress, primarily by building more detailed schedules and milestones into contract documents along with provisions that give the owner adequate powers to ensure compliance. In early projects, clauses governing schedule obligations tended to be too vague to ensure effective coordination at the operation level. In more recent projects, schedule development has been advanced sufficiently early to permit the inclusion of adequate milestones in contractual agreements.

Procurement problems have been among the most troublesome of those facing investment projects in both public and private sectors. Delays in import licensing have been widespread; so, to an extent, have been delays in procurement of controlled domestic items. FCI's experience has helpedit to adapt, to an extent, to these difficult circumstances.

The foregoing description of the considerable strides made in one industry in project planning and management suggests potentially significant economies to be realised as experience in investment planning in an industry accumulates, and as many of the engineering, procurement, fabrication and management functions are taken over indigenously. Over the transitional period, as additional functions are assumed bit-by-bit, the path of project costs is affected by a) start-up costs involved in doing something for the first time, whether it be designing an ammonia synthesis unit or managing equipment procurement; and b) costs stemming from loss of unity in management and control in the project and the consequent increase in problems of coordination and communication. Initial investments in an industry are likely to be implemented under unified turn-key contracts awarded to experienced foreign firms; as the process of import substitution in investment services approaches maturity, project control is likely to be re-unified under the owner or a domestic contractor. In the interim, the costs of disintegration in project management are likely to be felt in schedule delays due to failures in coordination as well as inexperience as new functions are taken over.

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APPENDIX

Calculations Leading to Table 2

The following calculations are in support of Table 2 of the text and are intended to show that the costs of under-utilized resources are a major source of inadequate returns to investment; or, to put it more positively, that the reserves of productive potential comprise an extremely promising source of internally generated economic growth. A relatively simple discounted cash flow analytical framework has been developed in order to demonstrate the effects of more rapid project completion and attainment of full capacity production on the net worth of the individual enterprises. The variables that enter the model are as follows:

X = full-capacity physical output rate, or volume index, per year

k = the total capital cost of the project per unit of output at full capacity production

p = the unit value price of output

e = direct operating costs per unit of output

C = total fixed costs

r = the marginal efficiency of capital, or social rate of time discount

A = the time at which production begins, measured from the start of investment outlay

L = the time at which production ceases, measured from A

V = the discounted present value, or net worth, of the project

$f(t)$ = the time distribution of investment outlay

$g(t)$ = the time profile of output

j = the percentage of investment outlay which occurs before production can begin.

Then, assuming that parameter values would be chosen to make $f(t)$ almost zero well before $t=L$ the expression for V is approximately

$$1) \quad V = \int_A^{A+L} (p-c)Xg(t)\,e^{-rt}\,dt - \int_A^{A+L} Ce^{-rt}\,dt - \int_0^{\infty} kXf(t)\,e^{-rt}\,dt.$$

A flexible and convenient form of the function $f(t)$ is the gamma function, which assumes a uni-modal distribution of investment outlay over time:

$$2) \quad f(t) = \frac{b^{n+1}t^{n}}{n!}\,e^{-bt}$$

which implies that

$$3) \quad \int_0^{\infty} f(t)\,e^{-rt}\,dt = \frac{b^{n+1}}{(b+r)^{n+1}}$$

As a specification for the function $g(t)$ an appropriate form would be a logistics-type relation which approaches unity as t increases:

$$4) \quad g(t) = 1 - e^{-a(t-A)}$$

$$5) \quad \int_A^{A+L} g(t)\,e^{-rt}\,dt = \frac{e^{-rA}}{r(r+a)}\left(re^{-rL}(e^{-aL}-1) - a(e^{-rL}-1)\right)$$

If one is willing to ignore a term as small as $re^{-(r+A)L}$, which should be very close to zero, then

$$6) \quad \int_A^{A+L} g(t)\,e^{-rt}\,dt = \frac{e^{-rA}}{r(r+a)}\left(a - (a+r)e^{-rL}\right)$$

and the whole expression can be rewritten as

$$7) \quad V = \frac{(p-c)e^{-rA}\left(a - (a+r)e^{-rL}\right)X}{r(r+a)} - \frac{Ce^{-rA}\left(1-e^{-rL}\right)}{r} - \frac{kXb^{n+1}}{(b+r)^{n+1}}$$

The start-up time A must be considered to be a function of the parameters of f(t), such that the sooner production begins, the sooner the investment is completed. For purpose of analysis, it can be assumed that production begins after a specified fraction of the investment has been completed.

$$8)\quad \int_0^A f(t)dt = j \qquad 0 < j \leq 1$$

thus determines A, given f(t) and j. It would be useful to express V directly in terms of the start-up time A. From 2) and 8) it can be derived that

$$9)\quad \frac{\partial A}{\partial b} = -\frac{A}{b} \quad , \text{ and so}$$

10) $Ab = x$, where x is a constant of integration. If one considers only integral values of n, this constant follows the relationship

$$11)\quad j = 1 - e^{-x}(1 + x + x^2/2! \ldots + x^n/n!)$$

If only n = 2 and j = .75 are used, the expression for V can be written in a final version as

$$(12)\quad V = \frac{(p-c)Xe^{-rA}(a - (a+r)e^{-rL})}{r(r+a)} - \frac{Ce^{-rA}(1 - e^{-rL})}{r} - \frac{kX\,x^{n+1}}{(x+rA)^{n+1}}$$

From this expression it is possible to assess the impact on the discounted net worth of the project of changes in the construction period, or in the period required to attain full capacity. Also, it is possible to re-formulate the model slightly to encompass a wide variety of financial arrangements. For example, if all investment funds were committed at the very outset, the last term of the expression would simply be -kX, with the rest of the relation unchanged.

In the following paragraphs, hypothetical parameter values are used to explore the impact of these gestation lags for projects of: a) different capital intensity, b) alternative financing arrangements, and c) different ex ante profitability. In all that follows, the choice of units has been such that the full-capacity physical output rate per year in each project is equal to unity (in tons, numbers, or whatever), and the price of this unit of output is also unity (in rupees). Therefore, total capital requirements, the discounted present value of the investment, and project costs will all be expressed in units corresponding to the value of one year's full capacity output. Conversion to units based on the total capital requirements of the projects is a simple matter, using the capital-output ratios. The production span of all projects has been assumed to be fifteen years, with no subsequent scrap value. The start of production has been assumed to occur after 75% of the total investment has been disbursed, a conservative assumption.

The simplest and conventional way of representing investment costs in such analyses is to assume that investment costs coincide in time with investment outlays. Although this is not usually true from the standpoint of the individual enterprise which finances investment substantially through borrowing, it is true from the national standpoint for all investments out of domestic resources. Even from the national standpoint, it is not true of the foreign capital component of investment, for which the resource costs to the economy (in interest, dividend and amortisation payments) may not coincide in time with the disbursements. The effect of this "pay-as-you-go" assumption is to minimize the cost of lags in the construction period, since such lags defer both benefits and costs. Table 3 below presents the discounted net worth V as a function of the time for start-up A, for various projects, based on the relationship (12). At discount rates of first 7% and then 15%, the procedure has been to choose projects with capital-output ratios k of one, two, and three in such a way that each would just break even (V=0) if production began after three years. This implies, of course, that the operating margin (1-c) must be much greater for more capital-using projects and at higher rates of time discount.

TABLE 3

PROJECT NET WORTH AS A FUNCTION OF PROJECT COMPLETION DATE

A. r = .07
C = .10

k=1; (1-c) = .24

A	Y
2	.014
3	.000
4	-.016
5	-.030
6	-.042

k=2; (1-c) = .36

A	Y
2	.03
3	.00
4	-.03
5	-.06
6	-.08

k=3; (1-c) = .49

A	Y
2	.045
3	.000
4	-.045
5	-.087
6	-.125

B. r = .15
C = .10

k=1; (1-c) = .34

A	Y
2	.03
3	.00
4	-.04
5	-.05
6	-.08

k=2; (1-c) = .56

A	Y
2	.07
3	.00
4	-.07
5	-.11
6	-.15

k=3; (1-c) = .78

A	Y
2	.10
3	.00
4	-.12
5	-.17
6	-.23

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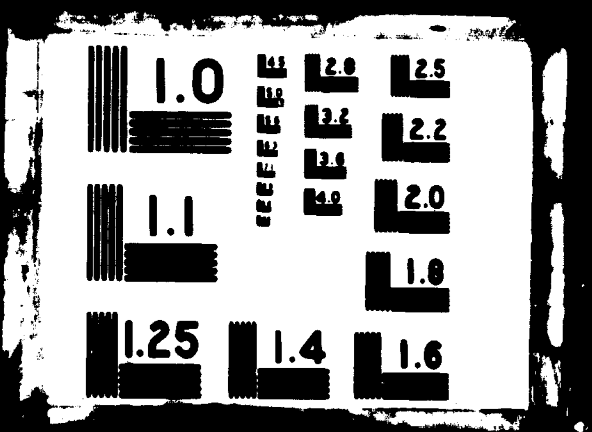

The results show that at the lower rate (7%) of discount, a one-year lag in project completion reduces the net worth of the project by about 1.5% of the total capital employed, a two-year lag reduces it by about 3%. At a 15% rate of discount, the costs are about 3% and 6% of the total capital employed for lags of one and two years. While these magnitudes are not negligible, neither are they earthshaking. It is interesting, however, to pursue the matter a bit further.

Delays in reaching full production after project completion, under pay-as-you-go financing, defer only the benefits and direct operating costs, and so are more damaging to net worth. In Table 4, essentially the same projects are re-examined for variations in this second kind of lag; whereas it was assumed previously that once completed, all projects would reach an output rate of 85% of capacity at the end of the second year (corresponding to a=1 in the distribution function $g(t) = 1 - e^{-a(t-A)}$), here it is assumed that all projects reach start-up at the end of the third year (corresponding to A=3) and the period required to reach full capacity varies. For greater intelligibility, the function g(t) is described in Table 4 in terms of only one characteristic: the length of time needed to reach 85% of the full-capacity output rate. The correspondence between this and values of the parameter a is illustrated below.

VALUE OF a	VALUE OF t: g(t) = .85	VALUE OF g(t): t=2
1.25	1.5	.91
1.00	2.0	.85
0.85	2.2	.82
0.75	2.5	.78
0.50	3.8	.63
0.40	4.7	.55

For a = .50, for example, production at the end of the second year of operations runs at 63% of capacity, and it takes 3.8 years to reach 85% of capacity, and so on.

TABLE 4

PROJECT NET WORTH AS A FUNCTION OF ATTAINMENT OF

FULL CAPACITY OUTPUT

A. r = .07
C = .10

k = 1; (1-c)= .24		k=2; (1-c)= .36		k=3; (1-c)= .49	
t: g(t) = .85	(V)	t: g(t) = .85	(V)	t: g(t) = .85	(V)
1.5	.03	1.5	.06	1.5	.07
2.0	.00	2.0	.00	2.0	.00
2.5	-.06	2.5	-.08	2.5	-.11
3.8	-.17	3.8	-.24	3.8	-.33
4.7	-.24	4.7	-.35	4.7	-.47

B. r = .15
C = .10

k = 1: (1-c)= .34		k=2: (1-c)= .56		K=3: (1-c)= .78	
t: g(t) = .85	(V)	t: g(t) = .85	(V)	t: g(t) = .85	(V)
1.5	.03	1.5	.05	1.5	.07
2.0	.00	2.0	.00	2.0	.00
2.5	-.05	2.5	-.09	2.5	-.12
3.8	-.14	3.8	-.23	3.8	-.32
4.7	-.20	4.7	-.33	4.7	-.46

The results show that delays in reaching full capacity have a substantial impact on the net value of projects at all capital-intensities and both high and low rates of discount. A delay of only six months reduces the present value by four to six percent of total capital employed; a delay of two years reduces it by twelve to seventeen percent. Taken together, Tables 3 and 4 demonstrate that, even under these simplest assumptions, changes in the time required to complete projects and get them into full production have important effects on investment returns.

In fact, however, the assumption that investment costs coincide with investment outlays is unrealistic for the larger part of India's development projects. Foreign credits have financed a considerable share of India's investments in industry and infra-structure. The availability of such credit is limited, and the financial terms are, in most instances, lower than the marginal efficiency of capital in India. For proper resource allocation, this portion of project costs should be charged at the time at which capital is committed and made unavailable for other purposes.

Tables 5 and 6 show the impact of lags in project completion and attainment of full capacity for the same projects investigated previously, under the assumption that one-half the capital is committed at time zero. Therefore, for the reference project, with A=3 and a=1, the calculations show the economic costs of tying up capital in advance of its utilization. At a time discount rate of 7%, this is about six percent of the capital involved in the whole project; at 15%, this is about thirteen percent of the total capital. In general, the figures demonstrate the larger gains to be had from more rapid fruition; a one-year reduction in project completion time saves about 4% of the capital invested; a two-year reduction saves 7%, at the lower discount rate. At the higher discount rate, the savings would be approximately 8% and 13%. An acceleration of the rate of capacity utilisation by six months would save 6% of the capital employed, and an

TABLE 5

PROJECT NET WORTH AS A FUNCTION OF PROJECT COMPLETION: A. CAPITAL TIED

A. r = .07
C = .10

k=1; (1-c) = .24		k=2; (1-c) = .36		k=3; (1-c) = .49	
A	Y	A	Y	A	Y
2	-.02	2	-.05	2	-.09
3	-.06	3	-.13	3	-.21
4	-.10	4	-.20	4	-.32
5	-.13	5	-.27	5	-.42
6	-.17	6	-.34	6	-.51

B. r = .15
C = .10

k=1; (1-c) = .34		k=2; (1-c) = .56		k=3; (1-c) = .78	
A	Y	A	Y	A	Y
2	-.06	2	-.13	2	-.20
3	-.13	3	-.28	3	-.42
4	-.21	4	-.42	4	-.63
5	-.26	5	-.52	5	-.78
6	-.31	6	-.62	6	-.93

TABLE 6

PROJECT NET WORTH AS A FUNCTION OF ATTAINMENT OF FULL CAPACITY OUTPUT: ½ CAPITAL TIED

A. r = .07
C = .10

k=1; (1-c) = .24		k=2; (1-c) = .36		k=3; (1-c) = .49	
t:g(t) = .85	V	t:g(t) = .85	V	t:g(6) = .85	V
1.5	-.03	1.5	-.08	1.5	-.15
2.0	-.06	2.0	-.13	2.0	-.21
2.5	-.12	2.5	-.24	2.5	-.35
3.8	-.22	3.0	-.40	3.8	-.56
4.7	-.30	4.7	-.51	4.7	-.71

B. r = .15
C = .10

k=1; (1-c) = .34		k=2; (1-c) = .56		K=3; (1-c) = .78	
t:g(t) = .85	V	t:g(t) = .85	V	t:g(t) = .85	V
1.5	-.10	1.5	-.23	1.5	-.35
2.0	-.13	2.0	-.28	2.0	-.42
2.5	-.19	2.5	-.38	2.5	-.55
3.8	-.28	3.8	-.53	3.8	-.76
4.7	-.51	4.7	-.90	4.7	-1.20

acceleration by two years more than 16%, at a seven percent discount factor. At a fifteen percent discount rate, these savings would be approximately the same, since the higher operating margins and higher discount rates largely cancel each other out. If one puts these figures together, it appears that the combined effect of, say, shifting to a more economical mode of financing, accelerating completion by one year, and attaining full capacity six months earlier would save an amount equal to roughly sixteen percent of investment at a seven percent discount rate, and twenty-seven percent of investment at a fifteen percent discount rate.

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