Consulting and Engineering Design in Developing Countries

Edited by Alberto Aráoz
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CHAPTER 1
CONSULTING AND ENGINEERING DESIGN ORGANIZATIONS IN DEVELOPING COUNTRIES

ALBERTO ARAOZ

Consulting and engineering design are activities of an intellectual nature, which organize and apply knowledge for purposes of investment and production. They are characterized by certain methods of work, or methodologies, and often by a multidisciplinary approach. The services produced are not just of a technical nature; the economic, environmental, organizational, and training aspects are important for a good formulation and execution of investment projects, as well as for the efficient operation of the resulting installations. There is an accent on professionalism and multidisciplinarity, which distinguishes the best consulting and engineering design organizations.

There are some semantic and definitional problems deriving from the use of different terms for these activities (e.g., consulting, consultancy, industrial consultancy (UNIDO), technical consultancy (India), consulting engineering, etc.) and for those who are engaged in them (often, contractors provide C&E services and on doing so they are acting as consulting engineers, and conversely when consulting engineers construct they act as contractors). Sometimes a certain term is incorporated into legislative texts and adopts a definite meaning in a particular country.

I shall use the set of definitions that were agreed on at the STPI meeting on consulting and engineering services (Caracas 1975), which are of an operational character. C&E services are rendered at different stages of a project (Table 1).

Consulting services comprise the preinvestment services as well as advisory services in the two other categories — project execution and operation maintenance — the rest being engineering services. Therefore, consulting services include preinvestment services (prefeasibility and feasibility), as well as services rendered to a client related to the coordination, control, and supervision of project execution, and to the operation and maintenance of productive installations; and engineering services (or engineering design services) include those related to project engineering (basic engineering, detailed engineering), to product design and engineering, and to other design activities.

Consulting services at the preinvestment stage may involve various disciplines — engineering, architecture, economics, finance, law, ecology, and occasionally even medical, psychological, and educational sciences — the personnel aiming to conceive and appraise a project so that a sound decision may be made. The contributions of professionals from the
disciplines must be integrated so that the result is based on estimates of various parameters, which may later change in value. Thus, there is a degree of uncertainty; input costs may vary, unexpected contingencies such as a geological fault may appear, a new and better technology may be produced, and so on.

Engineering services come into the picture when the main characteristics of the project have been decided upon and a technology has been chosen. They are mainly performed by engineers, collaborating technicians, and draftspersons. Uncertainty of the outcome is much lower than at the preinvestment stage, so that consulting services are "probabilistic," and engineering services are "deterministic."

C&E services may be classified in different ways according to the type of service, the branch of economic activity to which it is rendered, and the type of client. This classification allows a fine division that can be expressed in tabular form; examples are surveys made by UNIDO and OECD.

In developing countries, C&E services are required mostly by users in the public sector (ministries, planning commissions, regional development authorities, public enterprises, development banks, and institutions in charge of promoting industrial development). Private industry is usually a less important client. Small- and medium-scale enterprises are potential clients for a wide variety of C&E services, mostly in the areas of management, technical assistance, and information.

The cost of preinvestment consulting services is only a very small fraction—1–3% in most cases—of the total investment, but such services are crucial from the technical as well as the economic and social points of view. In a developing country, the intervention of a local consulting organization may mean that the project is conceived with much more relevance to local needs and conditions than it would be if a consultant from an industrialized country were employed. Local engineering may contribute further in maximizing domestic inputs.

<table>
<thead>
<tr>
<th>Services</th>
<th>Stage of a project</th>
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<tbody>
<tr>
<td>Preinvestment services</td>
<td>Prefeasibility studies (surveys, identification, evaluation); project feasibility study</td>
</tr>
<tr>
<td>Project execution services</td>
<td>Project engineering (engineering survey, detailed engineering, product engineering, organization and management, information systems); project implementation (procurement, construction-supervision); commissioning and start-up (includes personnel training)</td>
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<tr>
<td>Services for operation and maintenance</td>
<td>Production and maintenance</td>
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I shall use the term consulting and engineering design organization, CEDO, to denote the organization producing C&E services. Several types may be distinguished: private C&E firms, which restrict themselves to rendering C&E services; public C&E firms, which are similar to private CEDOs except that they are state owned; public organizations that supply C&E services in addition to other services — for instance, industrial research institutes, industrial design organizations, technical information centres; captive or in-house organizations in public or private enterprises, which may be called engineering departments, project departments, etc., and may be temporary or permanent; in-house organizations in contractors and in equipment suppliers, which frequently provide C&E services to their clients by formulating projects that will incorporate their goods and services.

C&E activities in developing countries are in general not fully developed. Domestic CEDOs tend to be weak, and demand is geared to a varying but important extent toward foreign CEDOs or their local subsidiaries and joint ventures. At an early stage of development, C&E capabilities tend to be concentrated in construction and civil engineering, as well as in preinvestment services in general. CEDOs devoted to industrial projects appear later on; as industrialization proceeds, the scope of their activities becomes wider, and in some cases basic engineering capabilities are achieved.

If a country does not have the capacity to produce C&E services, projects will be conceived, designed, and executed by foreign-based CEDOs, with the danger of inadequate technological solutions, the need to import capital goods and production inputs that might have been supplied locally, and the continuing dependence on foreign know-how and foreign skills.

CEDOs in developing countries have a wider and deeper role than those in industrialized countries. This is partly due to the more primitive conditions under which they operate, the relative ignorance and unfavourable attitudes of their clients, and other obstacles to their activity. The principal difference, however, lies in the important socioeconomic role they may fulfill by setting up projects that are appropriate to local conditions and by putting in motion a process that may produce significant impacts on development, beyond the contribution of the project itself.

When C&E activities are carried out by competent domestic CEDOs with knowledge of local conditions, the potential benefits for the investor as well as for the whole economy are more adequate technological solutions, clearly delineated investment packages, and efficient absorption of foreign technology and foreign consultancy inputs. There may also be a reduction in the cost of projects and their foreign exchange component, because local consultancy services are often cheaper and there is a higher proportion of local inputs than with foreign-based services.

Perhaps more significant in the long run are the favourable impacts outside the limits of the project itself. Locally designed projects tend to use more local inputs, thus increasing the demand within the country for capital goods, components, technology, services, and professionals. Bargaining power vis-à-vis foreign investors and technology suppliers may be increased. Knowledge may be spread more effectively among firms. New skills, attitudes, and capabilities are bound to be introduced.
throughout the industrial spectrum as widespread learning takes place. CEDOs may link up local research and development (R&D) institutions with the productive sector, taking charge of the engineering aspects of new technical solutions and providing technical assistance once industrial production has started.

The experience of several developing countries shows that such positive impacts on development have materialized as the management of knowledge by nationals has strengthened.

Some authors — of whom Perrin has been the most persuasive — feel that consulting and engineering play a unique and crucial role in industrial development, being at the crossroads of a flow of information and decisions between productive units, capital goods manufacture, and research and development. C&E activities link these three parts of the economic system and also provide links with the financial system. Through the projects carried out by domestic CEDOs, it is possible to maximize impacts from the productive units to the other two activities, thus promoting the development of an integrated industrial system. Industrial development without employing domestic C&E capabilities would rely indefinitely on imported technical solutions and imported capital goods (Perrin 1971).

C&E activities may, therefore, achieve a high social utility in terms of their impact on development. Two important national objectives would then be the increase in domestic C&E capabilities and their proper utilization so that a high social efficiency will result from the resources allocated to investment.

The public sector may play an important role in this regard. In many developing countries, the state has taken up growing responsibilities in dynamic activities such as petroleum, energy, transport, iron and steel, shipbuilding, heavy chemicals, pulp and paper, cement, etc., and public enterprises have become the main — if not the only — concentrations of economic power under national control able to face foreign-owned firms. They constitute important decision centres with the power to affect profoundly different sectors of national activity. Investment projects in these branches, however, have often been bought from foreign suppliers through turnkey purchases, and the participation of domestic C&E and industry has been limited. A change in traditional patterns of behaviour would have important effects on industrial development. Hence there should be an effort to open and examine investment packages, which often combine financing, technology, capital goods, construction, and technical services, to ensure maximum local participation in the supply of goods and services for the investment project.

A turnkey plant may be said to constitute an unknown package. The investors should be able to carry out their investments in a disaggregated manner, to have control of the technology, put the package together in accordance with the real national needs, and utilize fully intellectual and physical domestic inputs. To go from a turnkey operation to domestic control of technology and inputs, it is necessary to undergo a learning process that can rarely be accomplished in one step; thus, it is necessary to proceed through a series of stages that imply a growing mastery of technology — the development of domestic C&E capabilities and the adequate utilization of such capabilities (Sabato 1973).
There are costs in developing C&E capabilities and in accepting for a period some relative inefficiency, as happens with infant industries. One of the principal obstacles has been the risk to be assumed in entrusting national organizations with complex and exacting tasks. This, however, has generally been exaggerated in the past on account of poor knowledge and underestimation of national capabilities as compared with foreign capabilities that have been taken to be unexcelled. To this is added the frequent attitude of decision-makers in developing countries who look for an immediate effect of their decisions and purchases. They just want to obtain what they urgently need, to “get the job done.” By adopting such a short-sighted approach, they may lose important opportunities to improve the efficiency of their own organizations in future and to produce significant long-run effects on development.

There is, therefore, a good deal to be done in educating investors, banks, and governments regarding the key role of consulting and engineering for self-reliant development and the need to support and promote this activity through national policies. Ways and means have to be found in every country to transmit this message to decision-makers, industry, and often the consultants themselves.

**DEMAND FOR C&E SERVICES**

Consulting and engineering services are not products that feed final consumption in a society; they are inputs to other activities — investment principally — and as such their demand largely depends on the volume of those activities, which are themselves related to the extent of actual or planned changes in the country.

A distinction may be made between requirements and demand; the first term is the volume that should be demanded and the second is the actual volume demanded. It may be suggested that the demand for C&E services in a developing country tends to be lower than requirements, because project preparation and design are often made with less depth than would be desirable. If such tendencies were verified, there would be reasons for adopting policies for increasing the demand for C&E services to an adequate level, through persuasion, a decrease in the price of C&E services, or other means.

**SOURCES**

The principal sources of demand for C&E services in a developing country are the large investment projects in the public sector, which are carried out by ministries, public enterprises, development corporations, and other agencies. Such projects are usually included in national development plans. Other sources of demand are financial institutions like development banks and small enterprise development funds, which request consulting tasks for studies, programing, and project formulation;

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2 Foreign consultants have frequently made costly mistakes or recommended inadequate solutions that would have been easily perceived by a local consultant familiar with local conditions. On the other hand, a local firm may contract foreign expertise as and when needed. A more balanced assessment of the worth of local consultancy and a change in risk-avoiding attitudes is needed.
industrial firms carrying out investment projects (new plants or extensions), introducing new products, or adopting new production technologies; and small and medium-sized enterprises needing help for the acquisition of machinery, the improvement of management practices, and the solution of a wide range of technical problems. Demand originating outside the developing country may come from other developing countries, international financial institutions, and occasionally agencies of developed countries that extend bilateral aid usually preceded by extensive preparatory work.

The sources of demand may be classified according to the branch (civil works, mining, food industry, etc.), the type of technical service (building, power and light, water and gas, ventilation and air conditioning, drainage and sanitation, topography, etc.), and the stages of consulting and engineering services for projects (prefeasibility, feasibility, techno-economic work, process design, detailed engineering, procurement, product design, project start-up, project management, etc.). A series of two-way tables using these categories would give a detailed idea of the structure of demand.

This demand may be attended partly by in-house capacity and partly by outside CEDOs. The complexity of demand, to a large extent depending on the country's level of development, will call for more or less complexity in the structure of supply. Of prime importance in the case of semi-industrialized countries are multipurpose CEDOs that may attend the needs of the public sector, financial institutions, and large industrial enterprises. In countries of incipient industrialization, or in those with a very large traditional sector, CEDOs attending the demand of small and medium-sized enterprises would be of prime importance.3

Most of the demand for C&E services related to investment projects in the developing countries originates in the public sector. Any policy in favour of building up C&E capabilities and utilizing them adequately would therefore have to rely to a large extent on improving the behaviour of state investors, who should be influenced to adopt enlightened procedures in their investment operations.

**ESTIMATIONS**

It is not easy to estimate the demand for C&E services. It is probably better to employ as an indicator the volume of business (sales of C&E services) rather than physical indicators such as the number of drawings, personnel, etc. The volume of C&E services may be roughly estimated as a percentage of the expected cost of investment. There are few data on this aspect, but rules of thumb are that the cost of preinvestment studies (consulting) are around 3% of the total project cost in large industry projects and 1–1.5% in large infrastructural investments. The cost of detailed engineering would be between 5% and 9% according to the complexity of the project (Arãoz and Politzer 1975). This calculation is much too rough for reasonably accurate plans for the development and utilization of C&E capabilities, and a first research need comes out clearly:

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3 A network of consultancy institutions for small and medium-sized enterprises has been established in India, in close liaison with financial institutions for the same sector (Bhatt 1975).
to find out from past experience the value of such percentages for different types and locations of investment projects. This information would make it possible for a country to estimate the requirements for C&E for its main sectors and hence to plan the expansion and use of its C&E capacity.

In the case of preinvestment services, it is probably more difficult to arrive at satisfactory estimates than in the case of engineering and project implementation services. Sometimes investment decisions by the state are taken on political grounds, using a few a-priori elements, and the feasibility study may then become a formal requisite to justify decisions already taken. In other cases, investment decisions respond to one main factor, the availability of finance, and the study once again justifies a decision already taken. Preinvestment studies, then, largely become window-dressing. Similarly, the private sector sometimes justifies decisions in this way, although banking institutions and planning agencies are insisting more and more on the need to carry out careful feasibility assessments as a way to guarantee that good investment decisions will result.

Estimates of demand for C&E services should consider areas in which C&E services are bound to be required in the future and in which there is as yet little or no national C&E capacity. Long-term projections should be useful for identifying such areas. The formation of C&E capacity in them should be undertaken early if complete dependence on foreign CEDOs is to be avoided. Estimates may be made by an official organ, such as a planning authority, or by institutions, like the National Association of Consultants, that can study supply aspects in great detail.

There have been a number of experiences in demand estimation that have underlined the difficulties of the exercise. Demand projections were carried out in Canada, but the experience was not altogether successful, the conclusion being that only short-range predictions could be made because C&E activity is too much affected by the ups and downs of the economy to permit any reliable estimations in the medium or long term.4 This conclusion applies to a market economy, without explicit national planning; in a mixed economy with central planning, as is the case in many developing countries, it probably makes sense to devote efforts toward estimating the demand for C&E services several years ahead as a basis for programing the development of C&E capabilities.

In Algeria, for example, such estimates were a basis for the training of human resources. A fixed ratio of the principal industrial projects was used as the consulting and engineering input. This gave a good idea about the volume of studies and of detailed engineering needed, and from this figure, the number of working hours was estimated for professionals, such as engineers, technicians, and designers. Thus, it was possible to make rough estimates of the number of people needed by area of specialization.5

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4 This observation was made at the seminar convened by OECD in 1978.
5 A first conclusion from the exercise was that there were not enough training possibilities in Algeria. Priorities had to be set out, regarding both the engineering field and the phase of the consulting and engineering process, and it was clear that full utilization should be made of the opportunities of repetitive projects (Perrin 1971).
TRENDS

The demand for C&E services is already large in some of the developing countries and may be expected to grow significantly as major investment programs are undertaken. UNIDO estimates that industrial investment in all developing countries is close to U.S. $100 billion; if C&E services represent 5–6%, total annual demand would be in the order of U.S. $5 billion. Opportunities for CEDOs in developing countries would seem to be large, particularly because many projects are to be undertaken by the public sector. In India, for instance, it was estimated for the Fifth Five Year Plan some 25,000 professionals would be needed to handle all the engineering and plan design services, but only 6000 were available at the beginning of the period (Malhotra 1976).

The upward trend is apparently caused by the improvement in the economies of some developing countries, the preparation of more ambitious plans, a more intensive process of programing and implementation, a greater awareness of the role of consulting and engineering, and reorientation based on previous mistakes resulting from insufficiently detailed studies. Another influence is the increase in the share of C&E within total project costs, in part because C&E costs become more visible as the purchase of turnkey projects diminishes and also because there is a tendency to spend more on a wider range of engineering services in an attempt to save on the investment and operating costs of projects.

FOREIGN C&E SERVICES

In many developing countries there is a tendency to channel the demand for C&E services toward foreign CEDOs from industrial countries. If national C&E capacity is to receive proper utilization and thereby produce the social benefits expected from its activities, it is important to identify the reasons for such a preference and to lay down policy that will permit a redress of the situation as far as is convenient. Among the reasons are:

- The relative weakness of domestic CEDOs compared with foreign CEDOs, which principally comes from an inherent inequality in financial means and credentials. Domestic CEDOs are often caught in a vicious circle, which is very difficult to break.
- Attitudes in public and private enterprises that lead to the disparaging of domestic skills, the use of foreign consulting firms, and the turnkey solution. Such attitudes may take a long time to change because confidence in local consulting activity must be developed. In addition, decision-makers—particularly in the state—may have an attitude toward

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6 UNIDO presented this estimate in its document for the UN Conference on Technical Cooperation, Buenos Aires, 1978.

risk that makes them behave on the safety-first principle; this may become an important obstacle to the demand for local C&E services (Arãoz 1977).  
- Lack of domestic financing for C&E services; the client then looks for a foreign CEDO able to finance its services on easy terms.
- Lack of local medium- and long-term financing for investments, obliging both public and private investors to turn to foreign sources that finance the complete packages of consulting, engineering, technology, and equipment. This problem is dominant in countries that depend extensively on foreign aid and foreign investment, and the untying of aid has now become an issue in international forums.
- The behaviour of international financial agencies that, despite pronouncements to the contrary, favour the use of established CEDOs from the industrial countries.
- The behaviour of national financial agencies, which tend to copy the “prudent” behaviour of the international banks and, just as the latter, are often in favour of “getting the job done” and not complicating things with relatively untried local CEDOs or local inputs.

There are strong arguments for building up a national capacity in consulting and engineering and achieving import substitution in this field, although too strong a nationalistic attitude may act as a barrier to the flow of technology, it may impose tasks on the local CEDOs that they are not yet ready to discharge, or it may be negated in practice if weak local CEDOs take on foreign CEDOs as partners and leave to them the substantive work and the decisions that go with it. The problem is to use foreign C&E services in such a way as to maximize their positive features and minimize their negative effects.

**FLUCTUATIONS**

An important characteristic of the demand for C&E services in developing countries is its fluctuating nature. Economic cycles, stop-and-go policies, political changes, lack of long-term public investment programs, etc. are factors that lead to acute ups and downs in demand. There is a need for continuity if CEDOs are to work properly and develop steadily. The drying up of demand has not infrequently meant the disbandment of human groups that had been built up with much effort and the need to turn to foreign CEDOs when demand picks up again. On theoretical grounds, some idle capacity is socially beneficial in the long term in activities where, on the one hand, demand is not constant and, on the other, the length of services demanded is not uniform.  

Mechanisms must be found to support occasional idle capacity and to avoid disbanding groups when there is no work.

To even out state demand for C&E, first, government can introduce general regulations and carefully draft tenders and specifications. If regulations stipulate that local C&E services be used wherever possible, demand is bound to increase and become relatively more stable. Many influences act on state project owners. They have to decide whether they

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8 According to an Indian study, no government policy has been effective in forcing clients to use Indian engineering services or indigenously manufactured equipment (Malhotra 1976).

9 This result is well known in queuing (congestion) theory.
want to pay more to the consultant or to the equipment suppliers. In large package deals there is much C&E work that does not show; if packages are pulled apart, C&E costs increase but the total project cost may diminish. Also, they have to assess their desire to deal with one main engineering supplier, which may minimize complications and risks, and balance it with market conditions. Although it is generally accepted that C&E services should be bought by quality and not by price, sometimes price is considered to be more important than quality. Second, government can stabilize demand by analyzing development plans and by coordinating the different agencies that carry out investments. The latter may be difficult because agencies are often jealous about their autonomy. Third, the government can create demand for CEDOs by ranking projects according to priority and supporting low-priority projects when demand for C&E services is low. This has been successfully done in Brazil through FINEP (Financiadora de Estudos e Projetos), a government agency that funds studies and projects. Fourth, CEDOs themselves may try to adapt to these fluctuations. They can continue to work in spite of recessions by diversifying their activities, working outside the public sector, or exporting their services. In many developing countries, consulting organizations have a small core of highly qualified managers and few stable technical personnel; they rely on a large network of specialists for specific projects. When the work load diminishes, it is the outside collaborators who suffer; the firms continue to survive.

**FOREIGN DEMAND**

Some CEDOs in developing countries have been able to sell their services to other developing countries. This trend is bound to increase in some fields because these CEDOs have advantages over CEDOs from developed countries: they provide services at lower costs; they have an approach that is closer to the philosophy and way of life of the client; their awareness of local problems and local conditions is likely to be greater because of similarities between developing-country economies; and they may draw on technological solutions that have been tested and proved under conditions similar to those of the receiving country.

The export of C&E services is beneficial on several grounds. Foreign exchange is earned; national technology may be exported; and a CEDO may keep up its level of activity when local demand has momentarily dropped. Some developing countries have drafted policies for promoting such exports through tax measures, credits, and other means.

**SUPPLY OF CONSULTING AND ENGINEERING SERVICES**

**TYPES OF CEDOS AND THE STRUCTURE OF SUPPLY**

There is a clear tendency in developing countries — as has been the case in developed countries — toward the separation of C&E functions from other activities, as a consequence of the division of labour in increasingly complex societies.

A CEDO may be independent, producing services for various clients, or it may belong to a larger organization (such as a government agency, productive firm, contractor, or equipment manufacturer). These “captive”
CEDOs, often known as project departments, supply services principally to their parent organizations, but sometimes they do serve outside clients.

CEDOs may be owned by the state or private groups, local or foreign. They vary considerably in size and in the range of services they offer. There is competition between the different producers of C&E services in a country, but there are also relations of complementarity, which a policy for C&E promotion should consider.

In some developing countries, important sectors such as electric power, transport, steel, oil, and petrochemicals are in the hands of the state and carry out a succession of investment projects. They have a steady need for C&E services and tend to have their own C&E capacity; independent local CEDOs are used to supplement this capacity when peaks of activity take place, whereas foreign CEDOs are employed as suppliers of basic engineering and very specialized services.

Unless an enterprise or government agency has a sufficiently steady flow of new investment projects, it does not pay to house C&E staffs and becomes economic instead to contract outside CEDOs for most of these activities. This practice may be socially beneficial, as it allows CEDOs to become larger and acquire a great deal of experience, enabling them to render cheaper and better services to a variety of users, and to disseminate knowledge that otherwise would have profited just one customer.

Countries of incipient industrialization with a small modern sector have a small C&E capacity, mainly in production firms (particularly those of foreign capital), government project offices, and various public-sector institutions, including engineering design centres, industrial research institutes, productivity centres, consultancy units for small and medium-scale enterprises, and occasionally educational and training institutions. It is very important to employ whatever technical capacity is available for tasks of project formulation, design, and technical assistance. Industrial research institutions, in particular, are sometimes the only feasible alternative to import of C&E services.

Private independent CEDOs in developing countries range from very small firms with a high mortality to large, stable, firms. In many developing countries, there are numerous small CEDOs that carry out preinvestment services and a certain amount of engineering. They face a large number of problems, among them the instability of demand, the lack of confidence in the effectiveness of their services, and the fact that their clients often are not exactly aware of what they want and may not be capable of controlling the different stages of execution of a project. Frequently these small CEDOs look for foreign collaboration to increase their chances of landing an assignment. Their role is sometimes that of a commercial and administrative agent or a technical collaborator in peripheral matters. In other cases they carry out a great deal of the work. They are often organized as a small permanent group of able professionals who are joined temporarily by experts for a specific project. In the best firms of this type, those in the permanent staff have acquired a mastery of the technology of consulting, have a good knowledge of local conditions, and keep a

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10 Technology of consulting includes know-how about methods and their use, the utilization of outside expertise, the ways of presenting results and recommendations for different types of clients, etc.
dynamic system of contacts with users in the private and public sectors and with local and foreign sources of technology and equipment.

In some developing countries one also finds relatively large private CEDOs that are able to handle complex projects on their own. Frequently they also operate as contractors and carry out turnkey projects for their clients. Often they are subsidiaries or joint ventures of CEDOs from industrial countries.

India, Brazil, and other developing countries with a relatively important industrial sector show a well-developed C&E capacity in independent and captive CEDOs. In the case of India, Malhotra (1976) has pointed out:

- CEDOs may be classified in two groups according to their ability to provide project consultancy services. Most of the small organizations are in a position to offer only preinvestment or project planning services. It is only the larger organizations that are able to provide comprehensive project consultancy services.
- The small consultancy organizations have been forced to face keen competition from equipment suppliers who provide free consultancy services to the potential investors.
- A review of the activities of consultancy organizations indicates that so far no specific pattern has emerged. Although there are a few organizations (MECONS, Dastur & Co., Engineers India Limited, National Industrial Development Corp., etc.) that were originally established with the intention of specializing in particular industry areas, they have entered other fields as well. This may be due to difficulties in securing continuous business in their specific fields. But this diversification must necessarily reflect the quality of specialization established in highly complex fields.
- There are a fair number of reasonably well-equipped organizations in respect of economic, project, and management consultancy services in India. But not sufficient headway has been made in developing process and technological consultancy services. As a result, India still continues to depend heavily on external sources for the required process know-how and product-designing technology.
- The level of participation of consulting engineering firms in a sector varies according to the industrial sector served. This varying participation, to a very large extent justified by the different rhythms of technical progress observed by each sector, is also determined, to a lesser extent, by factors such as the possibility of access to the sources of know-how, the structure of the sectoral market, the links with groups in other sectors of the economy, and the links with capital goods producers and research institutes in the country.

A more typical situation is found in most Latin American countries, with a proliferation of individual consultants and small CEDOs with ad hoc, fragmentary, and individualistic characteristics, coexisting with some state organizations that produce C&E services and with a few large private CEDOs that often are foreign owned or joint ventures. Except for a few countries, most of the important investment projects are prepared and implemented by foreign CEDOs from the industrialized countries, with marginal participation by local people. The relatively recent emergence of local CEDOs, which did not exist before the early 1960s in most cases, the indifference of governments, the vicious circle, the strong fluctuation of demand, and the lack of financial means have been the main reasons for
this situation. Studies undertaken by the Andean Pact Secretariat show that by 1972 there were about 180 independent firms in the Andean subregion, which gave permanent employment to almost 1400 professionals. Most firms were small and were principally dedicated to physical infrastructure projects (transport, power, sanitary engineering, irrigation, telecommunications, urbanization, structures in general). In Chile, around 1974, about 15% of the total national expenditure for engineering was derived from private firms, 25% from foreign firms, and 60% from state organizations. In Venezuela, about 3000 professionals were employed in consulting engineering, but only a small proportion was organized in relatively important firms. Argentina has many small C&E firms, and a few large ones, which have had to cope with low fees, tardy payments, and a very fluctuating demand. The situation is similar in most of the other countries of the region, perhaps with the exception of Brazil, which for years has had a policy in support of domestic C&E.

Some other features of the Latin American situation should be noted. Local C&E capacity for services to industrial investment is much lower than for infrastructural investments. Local CEDOs often associate with CEDOs from industrial countries for a given job, but often there is no real collaboration between them, the local firm undertaking subsidiary responsibilities and sometimes acting as a mere agent. Some large CEDOs are subsidiaries of firms from developed countries or are joint ventures where the local associate is in fact a junior partner. The important C&E assignments tend to be entrusted to foreign CEDOs or to local CEDOs of foreign capital, whereas the locally owned CEDOs are employed in smaller projects or as subcontractors for the simpler tasks of large projects (Aráoz and Politzer 1975).

**SOME ISSUES**

**IMPORTS FROM DEVELOPED COUNTRIES**

The use of foreign CEDOs is sometimes unavoidable and is often regarded as convenient on grounds of speed, efficiency, and reliability; but there may be serious drawbacks, particularly in the long term. To minimize them, and to heighten the positive effects of employing C&E services from developed countries, certain types of procedures and rules should be applied. The purpose should be to employ foreign C&E as a complement to rather than as a substitute for local C&E, seeking mechanisms of cooperation between both to favour the maximum utilization of local sources and to make full use of foreign consulting as a vehicle for technology transfer and the training of national consulting personnel. Some people feel that the best solution is to employ a local CEDO as the prime contractor and let it determine what foreign collaboration it needs and how the work should be divided, with the proviso that it should establish a “relationship between equals” rather than just offering its letterhead and its offices to the foreign CEDO. This approach, however, finds obstacles in financial institutions and investors on account of their risk-avoiding, efficiency-seeking attitudes and their poor capacity to contract and use C&E services. Local CEDOs, on the other hand, may not feel up to the task in so far as they have become accustomed to a subsidiary role in regard to foreign CEDOs.
PARTICIPATION OF FOREIGN CAPITAL IN DOMESTIC CEDOS

The issues here are similar to those that have been extensively debated in relation to foreign capital participation in manufacturing and other economic activities. There are, however, certain peculiar aspects that have to do with the nature of C&E activities and the role they may fulfill in development. First, the extent to which a local CEDO is dependent on a foreign one is better indicated by the origin of its technology and key personnel than by the percent equity share of the foreign CEDO. Second, whereas foreign capital CEDOs present a number of advantages because of their ready access to the know-how and expertise of the parent organization, there may be disadvantages on account of a tendency to accept uncritically solutions imposed by the parent and to rely on foreign inputs without making a decided effort to use fully what may be procured domestically.

INSTALLED CAPACITY

As with demand, estimations of supply of C&E services are far from easy. Plain inventories of installed capacity on the basis of attainable sales volumes or of human resources available may be misleading. Some participants at a meeting of OECD in 1978 stressed the importance of the type of know-how that depends on the institutional organization; it was pointed out that skills, on the other hand, can be traded among institutions. C&E capacity, it was suggested, may be taken to be the total volume of human resources, economic resources, and technical procedures that are available at a certain moment to carry out C&E services; but these resources must be within certain types of organizations. Two computers and 200 engineers are only meaningful if they are in an efficient organization and have methods that can be used to prepare a project and follow up its execution. Therefore C&E capacity is only significant if there is appropriate capability to manage the organization and the projects it carries out. Hence, estimates of installed capacity are strongly related to the presence of management capabilities.

SPECIFICITY

How can specialized CEDOs be put to work in different areas? Do they have to recruit new people (or teams)? Can existing personnel be retrained in a short time? How can the new know-how be procured efficiently and quickly? Answers to these questions not only would throw light on the chances for survival of a CEDO when demand dries up in its specific field but would be helpful in debates about the establishment of a national C&E capacity when CEDOs have to be set up in several fields, because specific C&E resources may not easily be put to work in a field different from that in which they have specialized.11

STATE-OWNED CEDOS AND PRIVATE CEDOS

Private CEDOs in some developing countries have shown great concern about the expansion of state C&E activities, which they feel are encroaching more and more on their market. Although they are not

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11 Recent experience in Argentina has shown that CEDOs engaged in highway projects have found it difficult to switch to hydroelectric projects, even though the fields seem to be closely related.
against public-sector departments for the preparation of general studies and projects, they object to the growth of institutions that “without actually being consulting groups” absorb many resources destined for consulting. They feel that the proper role of state consulting lies in the promotion of expertise in new fields, which once developed should be set up as private CEDOs. They have doubts about the efficiency of state consulting and point out that top personnel are not easily attracted to government employment because of low salaries, that the best technical people move to administrative posts, that the pace of work in state organizations is much slower due to the characteristics of bureaucracy, and that political influences are much more persuasive. They add that private consulting is cheaper, though this fact may be hidden from view because a government organization often does not include in its costs the full amount of overhead items; sometimes only direct costs are charged. A cry of unfair competition comes from private CEDOs, who point out that they are strongly motivated to be efficient because their earnings, and indeed their survival, depend crucially on their efficiency, whereas public-sector CEDOs in general lack such a motivation.12

On the other side of the debate, arguments are that the profit-seeking nature of private C&E makes it vulnerable to ties with construction and equipment firms and with foreign CEDOs and that legal and administrative regulations and ethical declarations of principle are largely unsuccessful in curbing such tendencies. Another argument is that the small size of many sectoral markets for C&E services favours monopolistic behaviour by the few CEDOs (sometimes only one) serving a market. Moreover, certain areas of C&E are held to be legitimate interests of the state: such would be the case with industrial sectors like steel, petrochemicals, and mining where the state has a central interest or even a monopoly; with new activities where there is as yet no installed capacity in C&E; and with small and medium-scale industries that cannot meet the fees asked by private CEDOs.

The issue of state versus private C&E probably cannot be solved on rational grounds alone because it depends on contextual factors and on the political style of a country, which may or may not favour private enterprise. Within each country, there should be an attempt to identify the areas in which state-owned or private CEDOs are better qualified and to find out how state and private C&E may collaborate and complement each other. Some people think that the proper areas for the state are those of policy, planning, programing, and preliminary project conception — the strategical decisions — leaving to the private CEDOs the detailed and specialized studies, the preparation of preinvestment studies, and other tasks needed for tactical decisions, as well as engineering design and project implementation activities. Other people believe it is advisable for large public enterprises to develop strong in-house C&E capabilities, coupled with R&D activities, especially when this approach is the only way to acquire the engineering capabilities that are needed for technological autonomy.

12 These and other arguments are frequently invoked by national and international consultants’ associations in defending the interests of private CEDOs.
C&E Statistics and the Formal Emergence of a C&E Sector

One of the reasons why national policy in many developing countries does not deal explicitly with C&E activities is that the latter do not have a visible existence in the national system of statistics and do not constitute a formal sector or branch. Even though the magnitude of these activities is not large, their importance as organizers and executors of investments, and as suppliers of many different services to production, would justify their constituting a visible aggregate of economic activity to which policy may be applied.

It is possible, and indeed desirable, to measure the production, consumption, import, and export of C&E services, classified according to various criteria, and to relate such data to other economic, educational, and scientific indicators. Such information would help to diagnose the situation at different times and to lay out policies and plans related to C&E.

Although this should eventually be done within the general framework of economic statistics, the characteristics of C&E activities and services are such that it would seem appropriate to start measuring them within the framework of science and technology statistics. Most C&E activities would fall within the category "related scientific and technological activities" of the well-known OECD and UNESCO systems. A subsystem of C&E activities and services could be developed following an effort for drafting and testing operational definitions and classifications, perhaps under the auspices of an international organization.

Employing Domestic C&E

The use of domestic C&E services may produce a number of positive impacts on development beyond those that take place when a foreign CEDO is employed. Most of the effects are medium or long term and are difficult to measure because they are the result of applying certain ways of formulating and executing an investment project rather than other ways that were previously used. They are often social consequences, and they may be obscured by other influences. Some of the variables affected are qualitative, such as technical level, learning, and vulnerability, so that quantification of the effects is not simple and in some cases may be impossible. But it is worthwhile to analyze the different effects and to arrive, at least, at a general appreciation of their magnitude in a particular situation. This will perhaps be sufficient to provide clear guidance for policy decisions if, as would appear from the limited evidence so far, positive effects are high for certain ways of carrying out the investment.

How Decisions in the Project Sequence Are Linked

Certain decisions in the project sequence condition later decisions and markedly affect their relevance to development objectives. During project preparation — the preinvestment stage — the characteristics of the project are defined. Decisions at this stage have strong implications regarding the specifications and the origin of the goods and services that are to be procured in subsequent stages. A number of alternatives are studied as the work proceeds from project identification (when there may be a number of programing studies about the development of the main
economic sectors and of specific industrial branches), through prefeasibility (when a preliminary choice is made of the main project parameters, following from studies of markets, technology, location, etc.), and finally to the feasibility report in which more detailed market and location studies, preliminary engineering design, and tentative negotiations with prospective suppliers allow the organization to develop alternative technological solutions, submit them for appraisal, and make recommendations to the project owner, who actually chooses from the alternatives. But the organization doing the preinvestment work will have already taken a large number of preliminary decisions, which are incorporated in the alternatives submitted to the project owner, so that these alternatives may be more or less appropriate to local conditions, or oriented toward the use of local inputs, according to the approach and biases of that organization. Experience seems to show that when a local CEDO is in charge of preinvestment work, a better technological choice may result and more local inputs are likely to be incorporated.

Another important decision has to do with the way in which the investment project is financed. Experience also shows that the local content is highest when the investors use their own funds and lowest when supplier credit is employed.

Once an alternative has been chosen and financing arrangements, government approval, and other necessary preliminaries are ready, the project enters the execution stage, and a number of decisions have to be taken regarding the supply of inputs. The technological solution will have been selected already, and this generally means that a supplier of the basic engineering design will also have been chosen, either the technology owner or a firm that has been licenced by it. In many cases, the technology and the basic engineering design are procured outside developing countries; there is room, however, for detaching certain peripheral technologies from the core and getting them engineered locally. Also, it is sometimes necessary to conduct R&D work to adapt the process or the product to local conditions, and it should sometimes be possible to have this R&D performed locally. The extent to which the work on peripheral basic design and adaptive R&D may be carried out locally varies not only with the level of technical development of the recipient country but also with the attitudes and the efforts of the project owners and their consultant organizations.

The next task is detailed engineering, in which the basic design is converted into a set of detailed drawings and instructions for the purchase and installation of equipment and for the construction activities. At this stage, a number of seemingly minor decisions take place, which when added together may make up important differences regarding the characteristics and sources of the inputs to be employed. The participation of a domestic engineering group is important to ensure that local inputs are incorporated into investment and production as far possible.

It is through a large number of decisions of this nature that a local engineering group can fulfill a socially important role in specifying inputs that can be produced by local suppliers. At the investment stage, this will affect the origins of different capital goods, technical services, construction materials, and construction services. At the operation stage, previous design engineering decisions will influence the nature and source of raw
materials, basic inputs, components, parts, spares, technical services, and administrative services.13

One can easily see how important it is to have domestic control of the preinvestment and the design engineering activities if full use is to be made of potential domestic supply at the investment and the production stages of the new installations. Consulting and engineering organizations in charge of those activities should be well aware of the possibilities of local supply and should have the right attitudes regarding modifications in process and product design, specifications, standards, and delivery dates. They should appraise the risks and the extra cost — if any — in each local purchase and advise the project owner regarding the decision that is best in the long run. In this way they may have a decisive role in increasing significantly the social efficiency of the investment process.

PROJECT PARTICIPANTS

THE INVESTOR

By using local C&E services and by opening up the technological package, the investor may benefit in the short run from a reduction in the costs of purchases, as efforts are applied to certain activities that may have been disregarded before, such as more appropriate specifications, better quality control, and the search for new sources of supply. In a longer time span, the investor may be able to choose a better-adapted technology, lower the cost of many items, supervise closely the construction of equipment and fixed installations, and decrease vulnerability in future operations as a consequence of a higher proportion of local inputs. This may cause substantial savings in investment costs, as well as in operating costs later on. But, more importantly, the investor and the local CEDO it employs undergo a learning process that is bound to increase the efficiency of production and maintenance operations, permit better investments to be made in the future, and help incorporate a stream of product and process improvements, some of which may originate locally. The cumulative effect of this learning process, and of a similar learning process in the investor’s local suppliers, may be very important.

There are, naturally, some drawbacks. The investors have to bear the costs of building up their internal technical capabilities and may also have to face extra costs on account of higher prices, poorer quality, and dearer financing of local supplies. There are also the risks of technical failure and late deliveries, which often deter users from opening up packages, relying on local engineering, and buying from local suppliers; however, it is likely

13 For example, in a Latin American country some years ago, a number of simple industrial buildings had to be built. Some of them were designed by local engineers, and these used 75% of domestically produced steel; others, designed by foreign engineers, imported 75% of the steel required. The large difference did not result from different characteristics of the buildings, which were alike, but from the approach of the designers. Foreign engineers were not familiar with local steel and would only employ it when they were sure it would not endanger the structure. Local engineers knew well the local steel and employed it unless they were sure it would not be appropriate. The “safety-first” attitude of the foreigners, added to their imperfect knowledge of the local product, unnecessarily multiplied by three the steel imports.
that such risks have been exaggerated in the past and have resulted in the continuation of poor practices for too long.

Changes in project formulation and implementation to produce the benefits should be carried out with caution. There should be a careful realistic appraisal of how far it is possible to proceed with forward-looking practices on a given occasion, on the understanding that another step ahead can be taken at a later date. By following a stepwise process of change, the investors can build up solidly their technical competence and that of their CEDOs and can develop a network of reliable suppliers. Some risks, however, are unavoidable, particularly when suppliers are given a chance to produce something they have not produced before. But risks are a part of economic life, and those who do not risk do not gain.

LOCAL SUPPLIERS

Improved investment practices, particularly if they involve purchasing programs for some time in the future, are bound to benefit local suppliers through an increase and stabilization of demand that encourages application of resources and efforts for technological improvement, productivity increases, personnel training, and expansion of plant. Additional inducements for technical progress are the introduction of specifications that demand a higher level of accomplishment.

One of the results may be that suppliers improve their technological levels and learn to do new things, thus enlarging their markets. Such a consequence is well known in developed countries, where many technical innovations resulting from work for the government in aerospace, defence, and other areas have found their way into civilian applications. The suppliers are allowed and even encouraged to apply the know-how they have gained to new products in other markets. In developing countries, the industrial branches are less sophisticated, and the know-how does not usually come from original R&D but rather from technology imports, personnel training, engineering efforts, and a sequence of minor changes and innovations. But the phenomenon is essentially similar; it can be clearly observed in mechanical industries supplying parts to manufacturers of automobiles, ships, and other complex products, which have shown remarkable technical progress in some developing countries. It is possible through adequate purchasing policies to accelerate and orient the learning process; a good example is the role that French public enterprises played through their procurement policies in developing the capital goods industry in France in the early postwar period.

Suppliers may find some problems in going along with purchasing policies that are aimed at them by just one or a few customers. They may have to accept stiff conditions and face continuously the possibility of a sudden drop or cancellation of orders on account of a change in policy, a not infrequent occurrence in some developing countries.

OTHER PARTICIPANTS

When purchases are made from local suppliers, they may produce effects on other parts of the economic system through market and nonmarket mechanisms.

A rise in the output of suppliers produces demand increases elsewhere through the "multiplier mechanism," and if there is not enough idle capacity in personnel and equipment to allow a corresponding
increase in output, new investment may be needed (the "accelerator"). In addition, there may be significant "linkage effects," through which important changes in the industrial structure of the country result.

The magnitude of the multiplier, accelerator, and linkage effects would reflect the orientation and magnitude of the investor's demand, at the investment and operation stages, and could be significant when large investments are carried out, such as happened last century with railways and is taking place today in certain developing countries that have ambitious plans for expanding their petrochemical industry.

There are other effects, or externalities, that are not transmitted through the market and are, thus, less quantifiable but that may prove to be even more important for industrial development in the long run. They should be explicitly considered and their magnitude appraised, if only by means of qualitative judgments, when investment programs are being formulated. Among them are the favourable psychologic impacts of successfully employing local consulting engineers, disaggregating complex investments, relying on local technological developments, and utilizing local capital goods and other inputs in investment and production. This "demonstration effect" is potentially so important that a strategy for building up C&E capabilities and utilizing them for maximum impacts on development should carefully select its initial activities so that the chances of success are maximized and it should devote efforts to propaganda on the achievements.

But, more importantly, a number of technologic effects occur as human resources are trained, researchers' attitudes are improved, technical knowledge is diffused, and capabilities for problem-solving and for the improvement and generation of technology are reinforced throughout the industrial system — a learning process sparked by forward-looking investment activities and the backbone for technological self-reliance. CEDOs fulfill a crucial role in this process by applying new know-how when approached by different clients. In this sense, independent CEDOs help in the "socialization" of knowledge otherwise locked within enterprises.

**IMPACTS ON DEVELOPMENT**

Governments can direct impacts so that they promote the development of a certain branch of industry (say, electric motors of 10 horsepower) or type of producer (small firms in a particular region) by explicitly using as a policy instrument the considerable purchasing power of the public sector resulting from its investment activities.

Other impacts will be transmitted throughout the industrial spectrum by market and nonmarket mechanisms; perhaps the most interesting outcome is a widespread learning process that results in an increase in productive efficiency, a reduction in costs, and a technological progress that may allow new productive activities. It is suggested that investment projects should be designed and conducted so that they have strong positive effects on learning.14

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14 The importance of the learning process was pointed out to me by R. Carranza in a private communication.
Impacts on R&D activities, and on the utilization of R&D results, are also very important. In fact, the results of R&D in specialized institutions have little chance of being employed optimally if C&E expertise is not applied to evaluating them, finding possible uses, identifying clients and users, developing product and process designs that can be applied commercially, and in general carrying out the activities needed to transform a technical advance into a commercially successful innovation. Some R&D institutions have their own C&E departments—"technoeconomic services," "sales," "consultancy," etc.—whose job is to link R&D activities with prospective users. In other cases, the task is done by an independent CEDO. In some large public enterprises in developing countries (oil, iron and steel, power) in-house R&D and engineering departments work hand in hand to develop and apply new technology and may enable new investment projects with basic engineering of their own. At this stage a very high degree of mastery of technology will have been obtained.15

The final impacts on development are expressed in a change of structures and a modification in the values of macro variables such as employment, productivity, imports, qualified personnel, etc. Other influences are at work so that the contribution of local C&E in investment projects may not be easy to ascertain. The stage of development of the country is an important factor. In a relatively advanced developing country, the impacts are probably much more important than in a country of incipient industrialization. In fact, they may even help to overcome the blocking of industrial development at the end of the easy import-substitution stage, through substantial purchases of industrial products from the enterprises that are receptive to innovation and able to profit from it. The impacts result from a conscious effort to manage investment projects in such a way that demand is generated for those enterprises, purchase specifications are carefully drafted, adequate prices are agreed, flexible contracts are signed, and financial and technical support is provided. The positive effects not only come from the increase in demand and its repercussions throughout the economy, but also derive from the technical progress that suppliers are induced to make to respond to increasing technological requirements, from the widespread learning process that such technical progress causes in other parts of the industrial system, and from the restructuring of relations between public enterprises, foreign and national private enterprises, R&D, financing organizations, and the government (Sabato and Martin 1967).

The benefits may be partially offset by the costs implied in inefficiencies and failures of local producers, retaliation by countries that face a drop in their exports, monopoly situations, etc. Policymakers have frequently magnified these drawbacks and often have not been fully aware of the potential benefits.

PROCEDURES AND DECISION MODELS

To achieve maximum impacts, projects should be disaggregated, local supply possibilities studied, and purchases carefully programmed, prefera-

15 The CEDO analyzed in the Brazilian case study in this volume is a good example of how this mastery is achieved. See also Malhotra (1979).
bly in concert with the supplier branches. A procedure employed in Argentina classifies items into a "positive" list (the items are already being produced with the required quality at acceptable prices), a "negative" list (it is not possible to produce them locally), and a "probable" list (production may take place if several problems are overcome, such as small local market, quality, safety). Efforts toward supplier development are concentrated on the "probable" list. This approach may be used also for technological inputs; action would be taken not for productive firms but for consulting and engineering organizations, research institutes, and other organizations of the science and technology system (Sabato 1973).

Similar procedures may be used in the stage of operation of productive units, but the difficulties are increased because the project owners, functioning enterprises, deal with many supplier units. There must be a development of adequate administrative procedures to construct an effective purchasing policy including technical, financial, and training assistance to the suppliers.16

Regarding decision models for local procurement, there have been in France some interesting attempts at constructing formulas for the pricing of local inputs under different conditions, and it would be useful to analyze such solutions in detail. In Argentina, G. Gargiulo has analyzed the acceptability of higher prices for local components of atomic power plants. Local production of components has microeconomic, macroeconomic, social, and technological effects that should be identified. If the component is already being produced locally, with sufficient quality, the purchasing decision is based on a comparison of the local and the import costs, with due regard to existing incentives and protective tariffs for local production. If the component is made locally but not with enough quality, or if it is not yet made but could be manufactured, the indirect benefits brought about by local production should be taken into account. To produce the component, the suppliers need to increase their technical capabilities, in equipment, technology, and training. This step produces extra benefits to the firm, which otherwise experiences a slower rate of technical development. There are, however, extra costs occasioned by the rapid increase in technical capability. The valuation of costs and benefits requires the definition of quantifiable indicators and the solution of the price system that should be applied. This line of analysis has not been developed (Comisión Nacional de Energía Atómica 1974).

Far too little is known about the practical aspects of heightening and transmitting the impacts of investment activity. Many positive experiences have taken place in developing countries, and no doubt the practices currently employed in some industrial countries may also be valuable as examples. There is a clear research need to identify and analyze successful cases and evaluate the procedures and decision rules employed, from which guidelines may be prepared for the benefit of developing countries.

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16 An example is the "ancillary industries program" carried out by public enterprises in India.
EFFICIENCY OF INVESTMENT ACTIVITY

Investors are expected to maximize the efficiency of their investment activity, i.e., the relation of benefits to costs. How far is this achieved in the developing countries? Partial evidence shows that frequently investors respond to limited, short-run objectives and are up against limitations and constraints such as the unwillingness to assume risks, the lack of qualified technical advice, imperfect information about alternatives, restrictions imposed by outside finance so that they employ foreign CEDOs and the project is carried out in a turnkey manner.

It is likely that if a long-term outlook were adopted, internal limitations eased, and a certain amount of effort applied — in other words, if improved procedures were employed for project formulation, design, and execution, involving a domestic CEDO at all stages in a responsible role — more efficiency would be possible.

Extra efforts applied by the investors and their CEDOs to the investment activity produce an increase in the private efficiency of the activity, that is, in the relation of the benefit reaped by the investors to the extra costs they must bear. The efforts have a more than proportional return until an optimum is reached, when more efforts do not pay. The investors may get to a new optimum in a reasonably short time, by acting on aspects that can be modified rather quickly. Over a longer period, they may build up their internal capability, undergo a learning process, improve their purchasing procedures, set up a network of reliable suppliers, etc., and, particularly if during this period there is an adequate development of one or more domestic CEDOs on which the investor may rely, further improvement may take place as a succession of investments is carried out.

In employing turnkey operations, investors apply a moderate effort and obtain an efficiency that they regard as maximal (Fig. 1), feeling that extra efforts are not warranted and may even be counterproductive. But changes in attitudes, a more long-term view, the increasing use of local CEDOs, and improved purchasing procedures may allow them to reach a higher maximum of efficiency in a relatively short time and an even higher maximum in the long run. The differences in short- and long-term maximums are attained through successive investments, as learning proceeds and various effects are worked out. The long-term maximum would be the optimum from the private point of view in the case of investors’ making their decisions according to long-run considerations. But an additional increase in efficiency may result if efforts are joined with other investors — this is a distinct possibility in the case of public enterprises — so that CEDOs can accelerate their learning process, specifications can be unified (particularly in the design of peripheral installations), product varieties reduced, and larger consolidated purchases carried out at lower prices (Fig. 2). However, in practice, it does not appear easy to coordinate investors’ activities and unify their criteria and purchasing mechanisms.

Private efficiency takes into account only the costs that investors must bear and the benefits they reap. Meanwhile, what is happening to social efficiency — the benefits versus the costs to the suppliers and other participants? Reaching a social optimum may require greater efforts than are required in reaching an optimal private efficiency. Thus, incentive
Efficiency

Fig. 1. Efficiency in relation to effort spent by investors and their CEDOs on investment activities.

Effort

Fig. 2. Efficiency in relation to effort if investors operate jointly with other investors.

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mechanisms of various types must be introduced so that the costs will be borne by the community rather than by the investors.

The model of analysis I am suggesting is conceptual and qualitative, and it would not be easy to express quantitatively. However, a first observation that has strong policy implications is that the point of maximum private efficiency may be reached by the investors without any incentive other than their self-interest. It pays them to increase efforts up to that point. Now, if the increase in social efficiency from the original position (turnkey operation) to that corresponding to optimum private efficiency is very high, a great deal would have been accomplished already, without a special incentive policy because the investors should have learned how to improve their practices.17

The maximum private efficiency that can be attained partly depends on internal factors — for instance, the technical and managerial level, the correct appraisal of real risks — and partly on factors of the environment, among them, coherence of policy, stability, etc. Higher levels of private efficiency in investment activities will be reached when policy and institutions are stable and when public-sector investors follow a common rationale.

A further increase in social efficiency may follow from the application of measures to encourage investors to apply more efforts than strictly warranted on private efficiency grounds. Such measures depend on the particular circumstances: they may take the form of a subsidy to the investors to compensate them for the extra effort with its accompanying costs and risks; or they may be directed to suppliers to lower their costs through special credit lines, training schemes, technical services at low cost, tariff protection, etc.

There is at times a tendency to rush things, without adequate preparation, in an attempt to achieve too soon a high level of incorporation of domestic technology, services, and inputs. It is necessary to understand the limitations that exist: learning to produce results that can be incorporated in successive investment projects takes time, and progress is achieved by stages. An important question is how far to go in each stage. In other words, what percentage of local participation may be sought in successive investment projects?

17 For instance, the investors may have had to modify their previous attitudes; plan their strategy for carrying out future investments; study the possibility of using local technology, engineering, capital goods, and inputs; improve their technical and management structures to make them able to carry out the expanded tasks involved in opening up a package and dealing with local CEDOs; perhaps develop their own project formulation and engineering departments ("captive" CEDO) and R&D groups; develop and adopt adequate methods of analysis and decision rules to deal with the various activities involved in an investment project, particularly in regard to purchasing decisions; externally, assist their domestic suppliers financially and technically so that their efficiency and technical level may increase; schedule purchases far in advance and make this known so that suppliers will have expectations regarding the type of purchases and their timing, a fact that will reduce uncertainty and induce investments in physical facilities, training, technological improvements, new technology, etc.
CEDOs can be very different, and it is not easy to make general statements about them. For instance, they differ in the way they originate, and this fact may significantly affect their later development and characteristics. What makes them comparable is that they have to carry out certain activities concerned with the organization and application of knowledge, and they have to acquire the resources and abilities to perform those activities in an efficient way.

CEDOs, like other institutions, develop until they reach maturity when they are reasonably well equipped with human, physical, and intellectual assets; are large enough to perform efficiently; have stable relationships with their environment — clients, suppliers, government, banks, local and foreign CEDOs — and are able to fulfill efficiently their social role.

The problems of a mature CEDO are somewhat different from those of a CEDO in its developing stage, because one of the main imperatives of the latter is to achieve maturity. To do this, it may need special measures of support from the public authorities. This is why both stages are considered separately here. Policy issues in sectors where mature CEDOs exist are different from those where CEDOs are developing. International cooperation between CEDOs also acquires different characteristics according to the maturity of the weaker party.

MATURE CEDOS

I suggest that the performance of a CEDO should be appraised by its social efficiency (SE) — the impact of the CEDO on national development in regard to the resources it employs. The concept is related to that of social efficiency of the expenditure on an investment project and is not easy to quantify (Fig. 3). However, qualitative comparisons may be made of the SE of a CEDO at different times, and also between two different CEDOs of similar overall characteristics.

What influences social efficiency? SE seems to depend on the adequate performance of CEDO activities; grouped into three main categories, these are determination of the "products" to be produced; production, and distribution. Maximum social efficiency in these activities would be, respectively, a maximum social utility of the products, a maximum productive efficiency, and a maximum distribution efficiency. The better a CEDO performs in these respects then; the better its SE.

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18 This was discussed extensively at the meeting sponsored by IDRC in 1976, where a typology of "emergence patterns" was considered, ranging from professionals getting together and looking for clients, through a building firm that branches into C&E services, to the carefully planned creation of a large C&E department by a large production enterprise.

19 The indicators of "success" that are sometimes applied to a CEDO may not adequately reflect SE; for instance, the fact that a CEDO is profitable, or shows a good rate of growth, is a good measure of its commercial success but only a partial indicator of its social efficiency. To give extreme examples, the Red Cross probably has a large SE but is not profitable, whereas exactly the opposite happens with the Mafia.
Influences

Characteristics of CEDO
(internal factors)
Ownership, past history, organization and structure, operational practices

Characteristics of milieu
(external factors)
National: explicit and implicit policies (legislation, policies, and actions of government and its agencies); contextual factors
International: relations with foreign CEDOs, R&D institutions, enterprises; behaviour of international financial agencies; possibility of exports and opportunities for cooperation with CEDOs from other developing countries

Activities

Determination of "products" to be produced
(C&E services; externalities)
Social utility of products:
- Characteristics of demand (industrial branch type of service, determination of need through interaction with customer)
- Design for maximum social utility

Production
Productive efficiency: best productive practices; good management; efficient procurement and use of resources, especially personnel and information for maximum productive efficiency

Distribution
Efficiency of distribution: delivery of C&E services to customers and of externalities to other participants, for maximum efficiency of distribution

Results

Social efficiency
Impact on economic and social development in regard to resources used

Fig. 3. The CEDO in its mature state.
These activities themselves are influenced by internal factors that derive from the characteristics of the CEDO. Such characteristics have probably evolved in response to needs posed by the activities carried out by the CEDO and have also been influenced by the environment in which it performs.

**DETERMINATION OF “PRODUCTS” TO BE PRODUCED**

The rule for determination of products would be that, within its field of work, the demands of its clientele, and its production possibilities, the CEDO should aim at selecting its “products,” and “designing” them, in such a way that their social utility is highest. A CEDO produces consulting and engineering services that have a certain value for the client, but the utility for society may be different, because the prices that are relevant socially may be different from those that are relevant privately, and other costs and benefits may accrue to society on account of the impacts associated with the rendering of C&E services. The CEDO not only should do a good technical job but should carry it out in such a way as to produce long-run favourable impacts on the investor and also on other social participants, so that maximum social benefits are derived from the task. In the design of products, therefore, the CEDO must consider both the strict needs of the project and long-run impacts on the client and on other participants.

The problem, of course, is that the extra costs and risks of designing for maximum social impacts are to be borne by the clients, whereas the benefits brought about by those impacts may be capitalized by them only in part. Thus, it may be necessary to instill motivation and to provide incentives that will induce a socially desirable course of action.

A number of issues may be brought up regarding the social utility of the CEDO products. The first one is how to appreciate (let alone measure) this variable. What weight should be given to long-term impacts compared with short-term ones? It is likely that this matter can only be discussed properly within the framework of a development plan. Other issues have a more operative content. Can certain practices be applied for maximizing expected social utility? What internal characteristics (for instance, national or foreign ownership of the CEDO) help or hinder a high social utility? What policy instruments are best to promote maximum social utility? Research is needed to answer such questions.

**PRODUCTION**

One important objective for every CEDO is to attain maximum production efficiency; the production program should be executed in minimum time and cost, with adequate quality and reliability. This objective is a necessary although not sufficient condition for maximum SE.

There is much diffused knowledge about CEDO production, but little has been written about it in the case of developing countries. Here is an important field for research, which goes well beyond normal management problems on account of the peculiarities of a CEDO. One of these peculiarities is the nature of the principal inputs used by a CEDO: high-level human resources; and knowledge, technical know-how, and information of many kinds. The management of these resources is not simple, and current management literature is of limited value. Questions are numerous: What sort of professionals should a CEDO employ? How
should they be trained and kept up to date? How can they be integrated into an efficient team? What are the best methods of work? How is information to be procured, stored, employed? What links should be formed with local and foreign suppliers of technology and information? When is an association with a foreign CEDO useful?

The experience of CEDOs of industrial countries is more pertinent to questions of productive efficiency than to questions about the determination of products, and about their distribution, where peculiar conditions in developing countries and the nature and role of their CEDOs would seem to call for fresh approaches. Whereas in the industrial countries the well-structured socioeconomic context largely reduces the problem of a CEDO to that of attending the expressed needs of the client and attaining a high productive efficiency, in a developing country the situation is much more complex and the optimum social efficiency cannot be reached by acting only on production. The two other groups of activities require much attention, and often the CEDO will have to surmount adverse characteristics of the milieu.

**DISTRIBUTION**

It is not enough for a CEDO’s products to possess a high social utility. The products must reach users at the appropriate moment in a form that will respond to their needs. In this way the CEDO makes sure that the results of its production activity receive proper utilization and hence that the promise of social utility is realized. This is the problem facing those involved in distribution.

In a highly industrialized country the problem is not acute. Clients are able to state very precisely their needs for C&E services, and they have technical structures to absorb what consultants give them; the market mechanism takes care of most if not all the impacts on development of C&E services, the importance of external benefits being probably of small magnitude.

In a developing country there is a danger that the clients will not ask for the type of C&E services they need, that they will not absorb well the C&E services for want of a technical capability of their own, and that the potential external benefits of a CEDO’s work will not materialize because the participants are not aware of opportunities or are not capable of seizing them. To avoid such outcomes, every CEDO needs a good “delivery system.” This requires strong links with clients and receivers of impacts. The CEDO has to devote efforts to overcoming barriers such as unfavourable client attitudes, lack of a common language, lack of economic incentives for clients to contract local inputs, etc. The CEDO may even have to educate the clients and help them consolidate a technical group of their own.

The CEDO should ideally go beyond its strict duty of providing C&E services and engage itself in a larger task of identifying and educating other groups that may profit from the opportunities opened up by its activities. For instance, the CEDO may look for research centres and capital goods producers that could supply needed inputs, encourage them to bid, pass on to them relevant information, and so on. In this way the CEDO may perform its social task. This activity is costly and time-consuming and would have to be supported explicitly by the investor and possibly by public policy.
The national and international environments affect significantly a CEDO's internal characteristics as well as its activities. Major influences in the national environment may be divided into two groups, according to the degree of control that may be exerted over them. The first includes legislation, policies, and actions of government, its agencies, and enterprises. Within this group, there are explicit policies that are expressly designed to affect CEDOs and their activities and implicit policies that are directed to other institutions and activities but produce side effects on CEDOs. Among the problems hindering CEDO activity are the instability of demand, the lack of financial strength, and the competition from foreign CEDOs; if conditions are to be improved, implicit policies may have to be changed and explicit policies formulated and implemented. For instance, the implicit policies contained in the growth and pattern of public investment should be examined, because slight changes in timing may mean survival for some CEDOs; the establishment of a fund to permit a countercyclical policy such that contracts can be awarded to CEDOs for long-term studies when project work slackens may be all that is needed to stabilize demand.

The second group comprises contextual factors that cannot be quickly changed by modifying legislation, policy, procedures, or decision rules. Perhaps the most serious obstacle to CEDO development resides in the cautious, risk-averting attitudes of decision-makers, which make them opt for foreign suppliers. Other contextual factors relate to the administrative practices in government procurement, which are often heavy and cumbersome; the technical capabilities of clients, which are often low; the frequent lack of understanding in government and political circles of the importance of having strong domestic and engineering capacity and using it; the quality of university graduates that a CEDO recruits, etc.

CEDOs need not accept these limitations; they may try to modify conditions in their favour, influencing their national environment in different ways: seeking changes in legislation and practices, suggesting new measures, building up a favourable image, helping clients to create an internal technical capability of their own, etc. Some of these actions may be done by individual CEDOs, others by CEDO associations at a national or even international level.

In the international environment, two aspects are noteworthy. The first one has to do with the outside organizations that may affect the performance of domestic CEDOs, by influencing their characteristics and their behaviour: foreign CEDOs, as competitors; financial agencies; and suppliers of different inputs.

Foreign CEDOs may be strong competitors in the national markets, and the local CEDOs, by virtue of the usual selection procedures applied by clients, may find themselves unable to break a vicious circle in which lack of previous experience precludes them from getting contracts that may give them experience. This subject properly belongs to the developmental and not the mature stage of a CEDO; but it is likely that a certain measure of protection may have to be extended for some time to CEDOs that have recently achieved maturity, because foreign CEDOs may have strong advantages from the financial backing and export subsidies of their countries and from their proximity to and familiarity with owners of
technology and producers of capital goods. Foreign CEDOs often associate with local CEDOs for certain assignments. In such cases, there is the danger that the local CEDO will remain the junior partner, without participating in the main decisions; this should be avoided. In fact, associations with foreign CEDOs should be employed for gaining experience, training staff, and obtaining information.

Regional and international financial agencies often fund large development projects, and therefore their policies and practices have an influence on domestic CEDOs. The record shows that these agencies have principally wanted to "get the job done," although recently some of them have shown interest in using their loan operations to foster the development of national C&E capabilities. The behaviour of international banks is often imitated by domestic banks, and this gives more urgency to the redressing measures that can be taken.

A number of foreign organizations may be the source of important inputs — for instance, R&D centres, information systems, capital goods manufacturers, manufacturing firms, etc. The CEDO should maintain a network of relationships to have "on tap" information, experts, and other critical inputs.

The other aspect of the international environment has to do with the export of C&E services to other developing countries. Such exports have been taking place for some time, and it is likely that they will expand in the future for reasons already reviewed (lower costs, more appropriate technical solutions, a better understanding of conditions in the recipient countries, etc.). One of the principal issues is whether such operations of technology commerce can be kept free from the drawbacks that similar operations between developed and developing countries have had in the past and, furthermore, whether they may be endowed with characteristics that would give them positive social impacts in the receiving country, creating domestic demands for goods and services, contributing to the domestic development of skills and technical capabilities, and producing other desirable effects. This technical cooperation among developing countries (TCDC) may require positive guidelines expressed in international agreements, and incentives for operations that comply with them.

CHARACTERISTICS OF THE CEDO

A mature CEDO should have a mastery of the technology of consulting and engineering and a reasonable degree of competence in the technology of the area or areas it attends. For this it needs qualified, experienced personnel; good management procedures; organizational know-how; and other characteristics favourable to its efficiency.\(^\text{20}\)

The characteristics of a CEDO will be influenced by its environment, the origin of its capital, its degree of autonomy, its past history, and the

\(^{20}\) Malhotra (1976) points out that successful CEDOs in India show characteristics such as good management; tendency to recruit the best people and pay them well; acceptance of risks; good marketing; support from government or political sectors to obtain key contracts during their first few years of life; flexibility and willingness to go into new fields; agreements with foreign CEDOs; disaggregation of C&E services until only basic engineering is purchased outside; ability to offer the local investor a complete package from conception to start-up as well as technical services at the operating stage.
sector it attends; they will also be shaped by the policies and practices adopted by managers and senior staff members, volitional factors that find expression in the choice of the role, structure, strategies, etc.

CEDOs in developing countries often attempt to modify external factors in their favour. This action is an important departure from the practices of CEDOs in developed countries where the environment is favourable, or at worst neutral, rather than hostile.

Some underlying research questions are: How are stable and useful links forged with the various social participants? What role can the CEDO have in the formulation of sectoral development plans? What is the minimum size of an efficient CEDO in different fields, from heavy chemistry to small mechanical industry? How should it be organized to withstand the ups and downs of demand so common for C&E work in developing countries (for instance, a relatively small stable staff and an ample list of collaborators that can be drawn into projects as and when necessary)?

THE DEVELOPMENT OF A CEDO

CEDOs show different characteristics in their development over time, according to their origin, ownership, degree of autonomy, and sector of activity; but certain aspects and issues are relevant for many different types of CEDO.

The development of a CEDO to maturity is bound to be gradual, with, ideally, an increase in social efficiency as a function of time. The final goal is the mature CEDO functioning at a reasonable level of social efficiency, its action being guided by long-term objectives.

During the developing stage the CEDO principally guides its actions according to concrete, short-term objectives, the main purpose being to get to the mature stage. Ad hoc government policies may be required for the promotion and support of this process. The time needed to complete the process and reach maturity will be variable and will very much depend on the support received by the CEDO and on the characteristics of its environment (Fig. 4).  

An independent CEDO in a developing country faces many obstacles, due to the nature of its activities and to the environment in which it acts. Equity capital is scarce for C&E activities, and financing is scarce and expensive. Tardy payments when a job is done for the state put a strain on finances; competition and fluctuations in demand result in a high death rate. A small CEDO may be caught in a vicious circle; it cannot get the large assignments it needs to grow because it cannot show qualifications, never having undertaken large assignments before. Even when experience has been acquired, for instance through work as a subcontractor to a large local or foreign CEDO, other obstacles persist in the shape of legal and administrative requirements such as the need for offering financial guarantees.

It is no wonder then that many important CEDOs in developing countries are subsidiaries or joint ventures of foreign CEDOs. However good this may be from the point of view of survival and of productive

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21 Some CEDOs will never reach maturity, will remain at a low level of social efficiency, or will even disappear.
efficiency, it is often not good from the point of view of social efficiency. A country cannot depend permanently on foreign sources for the greater part of the work involved in organizing and carrying out investment projects, and sooner or later it will have to develop its own C&E capabilities.

State support is required for this. In some countries the tendency is toward public-sector CEDOs, in others toward independent private CEDOs. The principal role of the state regarding the development of a CEDO is to ensure it an expanding and stable demand; extend to it a measure of protection; make available sufficient credit; and help it acquire technology, experience, and a good human team.

There is not a unique model for CEDO development. The way the organization develops depends on circumstances. Paths and strategies are dictated by the concrete objectives to be achieved, but the process is gradual and relies on the acquisition of expertise and credibility in successive stages.22

22 The experience of successful CEDOs in developing countries should be examined. A first step has already been taken with the four case studies included in this volume. There is also a wealth of experience about CEDO development in industrial countries that should be examined critically for its relevance for developing countries. For instance, the OECD (Organization for Economic Cooperation and Development) studies have indicated that in the USA, CEDOs showed no established historic pattern of growth, many of them having started as boilermakers, mechanical or electrical designers, civil engineering contractors, or even construction material suppliers. Continuity of demand was extremely important. The early CEDOs gained diversification by accommodating a range of tasks along the specialties that made them leaders in particular fields (Brown 1978).
A developing CEDO should pay attention to a number of aspects, some of which have to do with its internal functions and others with its relations with clients and other participants:

- **Paths of development** — the areas in which the CEDO is to work; they come up as a result of an interplay between immediate market opportunities and long-term objectives. There is a danger of growing along an "easy" line, as market opportunities appear and clients "overburden" the CEDO, making for imbalances, too much specialization, and possibly shallow technical development. Thus the CEDO may find itself expanding greatly its economic analysis capabilities or its structural design activity, while subcontracting other areas of work. Or the CEDO may diversify too much through accepting all customers, stunting its technological capabilities. The CEDO should lay out its long-term objectives and develop fully one or two technological areas that show good promise; once mastery has been acquired in one area, the CEDO may move into a new one.

- **Acquisition of know-how and expertise** — the key to CEDO development; it may be said to comprise three interrelated aspects: human resources development, technology acquisition, and the development of management capabilities.

- **Cultivation of clients in a widening circle** — life insurance; it may mean a CEDO must help clients to acquire sufficient capabilities to deal efficiently with tasks such as the preparation of terms of reference, drafting of tenders, evaluation of bids, control of progress, etc. The clients or users must have their own technoeconomic capabilities and procedures that will guide their dealings with CEDOs and other suppliers.

- **Design of contracts favourable to CEDO development**; lump-sum contracts are usually preferred by clients, but CEDOs favour cost-plus-fees, as they often find it difficult to make accurate cost estimates because of unstable conditions in a developing country. A small CEDO may not be able to absorb the losses of a single contract, so this is a critical point.

- **Pricing policy**; many prospective C&E clients in a developing country, principally the medium- and small-scale enterprises, are not in a position to pay fully for the services they need. Sometimes such services are provided at a loss by special state institutions. At the other end of the scale, large state investors may give opportunities to developing CEDOs to bid for a large C&E task, for which a developing CEDO may have to charge more than usual because of high indirect costs such as employment of new management resources. This could perhaps be interpreted economically as a firm working on the rising part of its cost curve. The state client would be footing part of the costs of CEDO development; if it did not accept this, it is possible that the CEDO would be deprived of an opportunity to expand and to acquire more know-how.

- **Development of network of contacts**; the developing CEDO will need to devote efforts to develop a network of contacts internationally so that it may have good and prompt access to information, technology, equipment makers, and other suppliers of inputs for its work. It should also build up its relations with local research institutions and manufacturers, which should be close enough to permit it to discharge a socially important role as a link between domestic producers and users of technology and capital goods.
THE ACQUISITION OF KNOW-HOW AND EXPERTISE

The building up of a good human team, the acquisition of technological knowledge, and the development of management capabilities are interrelated. The development of human resources cannot be separated from the acquisition of know-how; and in particular the development of management requires it to absorb key technical knowledge.

The development of human resources should be in step with demand, or possibly somewhat ahead of it, if those resources are to be prepared for the tasks to be carried out. Ideally the CEDO should formulate a personnel development program. The recruitment and training of stable personnel are two factors that interplay. What type of recruits should be had and what training they should be given will very much depend on circumstances and opportunities; there seems to be no agreed procedure, and practices differ from firm to firm. Recruits may be fresh graduates, persons with 3 or 4 years' experience in technical work, or experienced professionals. In regard to training, two important elements are academic training at home or overseas and on-the-job training while assignments are carried out, particularly when this is done in association with a more experienced CEDO. It is important to use the training opportunities when there is collaboration with a foreign CEDO, but this may not be easy if the latter believes that it will raise costs or lengthen the job or if it is wary of helping the development of a potential competitor. These are aspects where explicit policy may greatly help, by inducing the local CEDO to maximize the use of training opportunities and the foreign CEDO to conduct the training.

The efficient operation of a CEDO requires the use of modern management techniques and needs the acquisition of expertise in handling complex tasks that are carried out by persons from different backgrounds. In organizing its program of work, the CEDO has to pay particular attention to the allocation of its resources to the best effect. It should operate in a businesslike manner, if it is to become cost-conscious and efficient; this should apply too in public-sector CEDOs. In this sense a cost-plus type of contract is not too effective. Attention should be paid to the setting of standards for executing consultancy projects, the control of costs, schedules, the quality of work, etc. All this may be embodied in standard procedures.

The acquisition of technology and expertise by the CEDO implies a lengthy learning process about which little hard data exist so far. In the first place, the technology of consulting and engineering should be mastered, including techniques such as demand analysis, project evaluation, mathematical model-making, electronic data processing, scheduling, design routines, drafting techniques, preparation of reports, etc.

Second, the technology of the sector to which services are rendered should also be mastered. This brings up some interesting issues:

- The technology should not only be in the minds of the CEDO’s staff but should somehow be incorporated in the organization itself, through specialized routines, computer programs, technical files, lists of technology, equipment suppliers, etc. This “firm-embodied” know-how may reinforce the aggregate knowledge of the staff, improve their efficiency, and allow a departing staff member to be replaced by a new recruit with little disruption.
Technology acquisition may reach different levels of depth and complexity. The mastery of basic engineering design would be an appropriate goal in the long run; other more accessible goals may be formulated for different times as a guide to the CEDO's technical development.

Noteworthy among the forms of technology acquisition and learning are the recruitment of experienced personnel; the repetition work that may be carried out for successive clients; the establishment of feedbacks from clients once assignments are completed (possibly through follow-up visits and meetings); the close interaction with R&D institutions, technology owners, and equipment makers; the further training of staff members through special programs; the formation of a special group to master a certain technology (such as a "process group" that can carry out development and pilot plant work); and very importantly the association, permanent or temporary, with an experienced foreign CEDO. It may be desirable for the CEDO to establish links, or even associate itself, with a foreign CEDO, either indefinitely or for the duration of a project. In the best of cases this may mean a quick way to acquire know-how, but there is a danger that a developing CEDO will remain a junior partner. Experience shows that the local CEDO usually has problems in gaining access to crucial data, obtaining manuals and operating instructions, and in general procuring written documents that collect and summarize years of experience. The CEDO should negotiate access to such information, which is vitally needed if there is to be an effective transfer of corporate knowledge. Government policy should support this, for instance, by requiring that the local CEDO should lead the project with the foreign firm helping to carry it out: the project director can then have direct access to the top personnel at the foreign CEDO's headquarters instead of having to go through the foreign personnel who happen to work on the spot. Training may also become one of the items of cost in a contract between a government and a foreign CEDO. There are several interesting experiences in the developing countries that are worth analysis for the types of agreements and the operating procedures that are best for technology transfer from a foreign to a local CEDO (see Perrin 1971).

BUILDING UP A NATIONAL CONSULTING AND ENGINEERING CAPACITY

Developing countries need to build up a national C&E capacity and put it to good use if they are to have control of decisions that are important for their development, employ their intellectual resources well, carry out optimal investment projects, and achieve a harmonious growth of their industrial sector. This is not likely to happen spontaneously; it requires promotion policies that aim to produce a set of CEDOs able to provide C&E services with efficiency and reliability. As benefits to the country as a whole are bound to be significantly larger than those accruing to the users of C&E services, it is logical that the costs of developing C&E should be shared by the country through appropriate government action.

23 For instance, through a full-disclosure clause in an agreement for collaboration on a specific project.
OBSTACLES

Certain obstacles in developing a domestic C&E capacity and using it efficiently are a result of the characteristics of investors, CEDOs, and other participants; other obstacles are a result of the local or the international environment. A study of them suggests some policies to eliminate them.

Small countries can only hope to install adequate C&E capability in a few fields, if at all. Policymakers are often not aware of the key role of C&E in carrying out better investments and contributing to self-reliant development; and frequently there is not the necessary political will to change things for the better in these matters. Public investment programs often lack continuity, and decision-makers tend to be too cautious, not fully trusting local CEDOs and suppliers and wishing to avoid any complications that may imply delays and costs in the short run. Besides, they are hampered by the usual systems of selection and contracting of suppliers, established by law or traditional administrative practices, which are not adequate for promoting technical development; thus, it is not easy for them to support tasks that go beyond immediate requirements. In addition, investors often have a limited technical capability to deal with CEDOs, negotiate technology purchases, and identify technical requirements of production problems.

External forces such as supplier financing and tied loans greatly reduce the investor's scope of decision; there is more latitude when financing comes from international agencies, although insistence on "getting the job done" puts the focus on short-term efficiency aspects rather than long-term ones. Domestic investment banks tend to behave like international banks and are not willing to take what they consider to be high risks. Self-financing allows the highest latitude for choice of CEDO, technology, and equipment; but few investors have it.

Domestic CEDOs face strong competition from industrial countries' CEDOs, which may show much more impressive credentials, promise better guarantees, and provide more favourable financial terms. Faced with the choice, real or imagined, between delays, uncertainty, and few guarantees, on the one hand, and speed and efficiency, on the other, investors frequently select a foreign CEDO. Short-term considerations prevail, and long-term ones, which might help in the reduction of technological dependence, are not considered.

Internal characteristics of clients, CEDOs, and other participants may change in time as development proceeds and learning takes place. Unfavourable government policies may be changed once identified. But many contextual factors are difficult to modify; although some of them may be overcome through persuasion and strong incentives, others have to be accepted as part of the environment. As to the obstacles that originate in foreign participants, the country may adopt defensive policies and also join other developing countries in a united front to bring about changes in the international environment.

STRATEGY

An efficient approach to the building up of domestic C&E capacity should not just rely on policies "from the top." It should seek to promote actions from the participants themselves so as to put in motion a cumulative and expanding process that will overcome obstacles, change
attitudes, and bring about CEDO development and utilization as a
consequence of the interest and efforts of those involved, complementing
this with adequate policy measures at the right moments. Persuasion, the
diffusion of experiences from home and abroad, and the training of
responsible officials in investing enterprises are general measures that can
be taken early. As the process gets going, a number of general or sectoral
policies may be adopted to support it, and at the same time existing
policies may be revised when they have a negative influence on the
development and use of C&E capacity.

Within this general strategy, many specific actions may be taken. Which ones,
and in what order, will depend on the context, the opportunities, and the interest and eagerness of the participants. It is
possible, for instance, that major advances can only take place when there
is a balance of payments, and investors — particularly public enterprises —
have to turn, faute de mieux, to local CEDOs and local suppliers. If things
turn out well, the terrain that has been gained may be kept. It is likely that
the process cannot be planned in detail and that it is rather a case of
"disjointed incrementalism" as outlined by Lindblom and Hirschman, the
pursuit of an objective when there is only a general idea of where it lies and
little knowledge of the obstacles, like crossing a minefield with the help of
a mine detector.

The way in which a national C&E capacity is organized will be different
for different countries and for different fields where C&E services are
needed. Certain strategic choices must be made so as to define objectives
that will guide policymaking and action. These choices must address:

• The problem of priorities regarding the type of service and the
industrial branch in which C&E capacity should be established first. It has
been suggested that priority should be given to preinvestment studies first
because these are required for principal decisions that shape the way
investment projects are engineered and implemented. After preinvest-
ment, a second priority would be detailed engineering, an activity that
allows the links with the capital goods industry. Priority should probably
be given to the branches in which there are possibilities for repetitive
investments that will maintain a demand and allow experience to be gained
in successive tasks. Repetition possibilities for engineering are present in
peripheral technologies used by many different investment projects; to
make use of them it is necessary to disaggregate investment packages and
parcel out contracts.

• Degree of autonomy and specialization. Which combination should
be favoured — private or state-owned CEDOs, independent or captive,
specialized or multipurpose? Much will depend on the prevailing opinion
and the "style" of the country concerned. State-owned CEDOs, how-
ever, would seem to be a necessity to serve small and medium industries,
which cannot pay fully for the services they require. Independent CEDOs
may sometimes offer advantages over captive ones both from the private

24 One country, through its National Development Bank, has created technical
groups in areas like forestry and has made them private after some time, continuing
with its support in the shape of assignments and credit. In India, the government
has tended to build up its own C&E capacity; government CEDOs act as prime
contractors in large projects and subcontract certain parts to private CEDOs.
and from the social points of view: clients would not be saddled with project offices that are active only part of the time, and such CEDOs probably have a stronger impact on the diffusion of knowledge by virtue of the many clients for which they perform assignments. But large enterprises may prefer to have their own captive capacity, which allows them a high degree of mastery of the technology in their branch, particularly if R&D activities are also carried out and secrecy is a consideration. Multipurpose CEDOs have fewer problems associated with demand fluctuations, but this approach tends to disperse efforts, particularly of key management personnel. However, in small countries diversified CEDOs may be unavoidable. A closely related question is whether CEDOs should be totally independent of ties to technology owners, contractors, capital goods producers, and other commercial interests. This issue has been debated for a long time. National and international CEDO associations maintain that the clients can only get proper and unbiased advice if the organization they retain is not tied to any other interests, and they have incorporated this principle in their codes of conduct. However, international banks allow CEDOs related to such interests to participate in the formulation, engineering, and supervision of investment projects provided that their associates do not supply any inputs. In a developing country there are reasons that the principle should not be absolutely upheld: for instance, a captive organization belonging to a contractor may sometimes represent the best domestic source of C&E; the volume of business and particularly the profits will be much larger for a CEDO that is integrated within a larger commercial operation, such as a contractor, significantly increasing the chances of development of the CEDO; this argument is important from the point of view of developing an indigenous CEDO capacity; in any case, many developing country CEDOs have originated in civil constructors and other enterprises that established an engineering department that later became large and went on to supply services to other customers. In certain sectors of some countries — for example, CEDOs in the process engineering branch in Argentina and Mexico — C&E capacity is already extensively tied up with commercial interests.

- The organization of CEDOs nationally and sectorally. In some areas the expected work load may not justify more than one or two large CEDOs; the danger is that there would exist strong competition and a high death rate among many small CEDOs, none of which could aspire to become large enough to carry out an efficient task, so that foreign CEDOs would continue to be employed indefinitely in key assignments. A monopolistic situation may be the only alternative to such foreign domination, contracting and pricing procedures being negotiated and agreed.

- Relations with foreign CEDOs. A position should be taken regarding the place of foreign-controlled and joint venture CEDOs.

The support awarded to developing CEDOs is essential if they are to reach maturity. The main questions are: How much support should be given to private CEDOs (a) directly through fiscal incentives, loans, and other means, and (b) through contracts for which relatively high rates are paid? How much should be invested to create and develop state-owned CEDOs in certain key areas and branches? What amount of subsidy should be given to the C&E services rendered to small and medium industry by
information centres, industrial research institutes, and other organizations catering to that sector?

**POLICY**

Some policy measures and actions can be taken by users and producers of C&E services, and by the government, to help the development of national C&E capabilities. Most have been discussed elsewhere in the literature; others have been put forth in conferences on C&E or have derived from personal conversations with different people. In some cases they are being applied in developing countries, as shown in the case studies included in this volume.

**USERS**

Measures and actions by the users of C&E services include:

- Careful appraisal in selection of a CEDO based on expected performance. Selection should not be influenced by price considerations; or by financial facilities; risk-avoiding attitudes; too much reliance on credentials, especially those of a foreign CEDO. Methods of selection should give domestic CEDOs the possibility to overcome the “inherent inequality” they suffer in regard to foreign CEDOs.
- Use of enlightened practices in the preparation and implementation of investment projects. Local CEDOs should be given significant responsibilities as well as opportunities to train their personnel and acquire know-how even though this may signify a cost.
- Development of their own technical staff to deal with suppliers. It will often be convenient to build up a true technical and engineering capability. The process of creating this internal capability is not simple; it is not enough to hire professionals; a team should be formed.
- Careful handling of relations with CEDOs. Terms of reference should be precise but flexible. The users should control carefully the work of CEDOs and other suppliers. They should integrate their own personnel into the CEDO’s technical teams for a better overseeing of the work and as a means to train people who will later be engaged in operation and maintenance. They should provide the necessary feedback information to allow the CEDO to learn from its past work.

**CEDOs**

CEDOs in developing countries can do much by themselves to increase the quality and scope of their activities:

- They should program their development, establishing concrete objectives over time and marshaling the means to achieve them.
- They should attempt to utilize fully the resources and skills available in the country, establishing strong ties with various institutions — universities, research institutes, development agencies, banks, equipment makers — and at the same time creating links between them for the benefit of an integrated industrial development.
- They may pool resources to carry out large assignments. This does not exclude foreign inputs through joint ventures or individual consultants to carry out specialized tasks.
- They should form or strengthen professional associations of consultancy organizations, which can be useful in raising professional standards.
through registration, establishment of codes of conduct, exchange of experience, and improved communication channels.

- They should develop quality assurance mechanisms so that a solid and reliable structure of C&E services is created. In developed countries, the profession of consulting engineering usually has a self-policing mechanism, such as the periodic renewal of a qualification, which gives the user some guarantee as to quality. In addition, large CEDOs continuously check the quality of the work in their various projects and can change the project managers and their professional staff if necessary. But CEDOs in developing countries may have just one or two projects that are managed by the principals of the firm. This fact points to the need for a central organization, possibly set up by a CEDO association, that supplies reliable information to prospective clients, helps in drafting guarantee and bonding clauses, and carries out a control of the quality of services rendered.

GOVERNMENTS

Governments should ideally define a long-term program for the development of C&E capacity at national and sectoral levels, with clear objectives according to the choices made on several aspects of strategy. Within the program, specific policy measures may be adopted at the appropriate times.

Government policies on the demand for C&E services include:

- Adoption of political support and the right attitudes, which may vary from branch to branch. For instance, atomic power development in Argentina and India relied from the beginning on domestic C&E efforts, disaggregation of packages, increases in local inputs, etc., whereas steel and other industries in the same countries relied on turnkey projects for a long time. The government may influence attitudes and behaviours through persuasion and other means.

- Awarding of contracts directly to local CEDOs. The government can adopt legislation favouring the use of local (in preference to foreign) C&E in public investments, although in practice this may not work too well as decision-makers invoke urgency, safety, etc., in their justifications for using foreign sources.

- The protection of domestic C&E production through a system of preferences. The usual tariff mechanisms do not appear to be effective because of operatives peculiar to C&E activity. C&E services are bought — or should be bought — on grounds of quality rather than price, and, in this regard, there usually is a bias in favour of what comes from an industrial country; price incentives are largely inoperative because the customer prefers to pay more if necessary — this is only a small part of the investment cost — and to feel confident that the most reliable and best quality services have been acquired. The application of regimens for the control of technology imports, foreign investment, and industrial property rights does not provide enough inducement to select local C&E services. There are many factors in technology choice that escape those regimens; some of them are subjective; others depend on how activities that demand technology are organized, who takes the decisions, and what decision rules are applied. To act on these factors and favour the contracting of domestic C&E services, governments may use preference systems of a qualitative nature. Domestic CEDOs face stiff competition from foreign
firms and are at a disadvantage on account of an inherent inequality in financial means and credentials. To eliminate this disadvantage and, further, to tip the balance in favour of local CEDOs, governments need to do two things: first, to devise financial mechanisms that would grant adequate credits to CEDOs (for their capital requirements and the preparation of proposals) and to their clients (so that consulting and engineering services may be had on favourable terms); second, to devise a method of selection on the part of the client in which the sheer volume of background experience and the renown of professionals do not automatically determine who is to be awarded a contract. Such a method would include the development of a point system with standard procedures for the assessment of the quality of a firm and of its proposal without undue emphasis on the volume of background experience and the awarding of extra points if the firm is local.

- Regulation of demand in the public sector so that CEDOs are not exposed to great fluctuations in the work load.
- Promotion of exports of C&E services through identification of likely foreign customers, use of embassies and missions overseas to assist local CEDOs, provision of tax rebates and subsidies for the export of C&E services, etc. In some countries a special trading company has been jointly founded by the government and exporters of technological services.

Policies on the supply of C&E services include:
- Establishment of state CEDOs in certain areas of the economy. In some cases these may be captive groups that are pulled outside their parent organizations and given a wider role.
- Preferential tax treatment to CEDOs for activities such as the export of services.
- Creation of credit facilities from which CEDOs may obtain working capital, training, research, technology, etc.
- Support for the establishment and functioning of consultants' associations.

Policies on the activities of CEDOs should aim to improve the social efficiency of CEDOs and that of the investments they serve. Examples are:
- Support for improved, enlightened practices that mean high social efficiency. This will require persuasion and, perhaps, the teaching of such practices to investors and CEDOs.
- Adoption of legislation compelling investors to acquire a percentage of their inputs from domestic CEDOs and local suppliers. This type of action has been very effective in the case of inputs for automobile production, where local subsidiaries have been forced to "integrate" their production. In the case of C&E services, success is less likely. Experience in Argentina and other countries shows that such legislation is frequently bypassed by public enterprises. It is possible, however, to establish a control mechanism, as has been done in Brazil and in India.
- Introduction of regulations that use foreign CEDOs positively for technology transfer and training. Such regulations may be implemented, for instance, by a technology registry that approves all technology agreements.
- Promotion of relations between CEDOs on the one hand, and R&D organizations, equipment makers, and input suppliers, on the other. The government may play an important part in this through its financial,
administrative, and technical units, acting in accordance with a central policy.

**INTERNATIONAL COOPERATION**

Positive policies, especially by governments, will encourage appropriate international cooperation with both developing and developed countries. Cooperative efforts among developing countries in technical matters are especially important not only in the sharing of technology but also in the reorienting of conditions now permeating operations of technology transfer, foreign investment, etc.

Technology may be shared through traditional channels (bilateral and multilateral cooperation) and through commercial channels (operations of technology commerce between a supplier in one developing country and a client in another). Technical cooperation through commercial channels offers great promise of expansion. The operations may be of benefit to the exporting country in terms of a greater mobilization of its C&E potential and the expansion of markets for its CEDOs. The receiving country may benefit through lower costs, the possibilities of obtaining more appropriate technologies, and the likelihood that such transactions will create much weaker links of dependence and will be endowed with characteristics that make them socially useful for the receiving country, helping the latter to build up its own C&E capacity. Cooperation of this sort may lead to the creation of large technology markets, the establishment of joint programs and joint institutions in certain fields, and eventually the achievement of technological integration between two or more countries. A small country may not find it easy to develop independent C&E capacity in certain fields, and cooperation with other countries may be the only way to obtain a C&E capacity that responds to its interests. Examples may be found in the Andean, the Central American, and the Caribbean subregions in the Americas.

The developing countries should cooperate to carry out a "technological diplomacy" to improve the conditions now ruling in operations of technology transfer, direct foreign investment, and others that may influence their technological development. The negotiations being carried on in UNCTAD (United Nations Conference on Trade and Development) and other international forums on "codes of conduct" for technology transfer and multinational corporations should be continued.

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25 A large part of the technologies needed by developing countries are already used by other developing countries and have been mastered by them; the "technology gap" between developing and developed countries as a whole is significant only in certain areas and branches, mainly the "science-based" type. Also, adaptive efforts, innovations, and cumulative production experience have produced "appropriate" technical solutions in many fields. Such solutions constitute "technological assets" that in many cases are implicit in existing plant and operating practices. To transfer such technological assets, it is necessary to make them explicit, i.e., to derive a "conceptual engineering" from existing practice. This needs technical efforts of the "reverse-engineering" type, which may be forthcoming if there is a market for such technological assets. With the conceptual engineering in hand, a proposal may be prepared in such a way that it incorporates the "basic engineering" of a project that fits the clients' needs and contemplates the local conditions under which they operate.
actively, and it would be convenient to start other actions to change the behaviour of various participants such as international and regional development banks, productive enterprises, CEDOs, donor agencies, and banks of the industrial countries.

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