Technologies in Developing Countries

Systematic outlines for collecting methodological elements of evaluating levels of technology

BY PROF. GIAN FEDERICO MICHELETTI*

Labor-intensive technologies and/or highly sophisticated technologies for emerging countries: these are the terms of the question I have received.

G. Micheletti

Experts in macro- and microeconomics and social psychology whose contribution is fundamental, might certainly discuss this subject in a much wider way. As for me, let me adopt a very concise and schematic way of speaking taking into account my typically technological way of thinking as well as the time at my disposal.

First of all, I should like to suggest a definition of the role played by the technologist specialized in the transfer of technologies and specifically in the transfer of technologies from industrialized countries to emerging ones.

The technologist must have:

—An analytic and synthetic knowledge of the specific technologies about which he is consulted, besides the applications already implemented or to be implemented.

—An accurate evaluation of the operative premises (availability and kind of energy sources, basic technical infrastructures and "ad hoc" utilization) according to which the suggested or requested technology has to operate.

—At the same time a realistic evaluation of the availability of such premises in the area where the technology is to be introduced.

—A full explanation about technical needs concerning operating, maintenance, repairs, life.

—Concrete perspectives of reliability, modularity, flexibility and limits of obsolescence.

—Specification of the technical requirements of the labor either temporarily made available by the transferor of technologies or to be trained on site with relating problems of instruction and training (where, by whom, how long, by which means).

Besides all these requirements which are all essential and the contents of which must be acquired by experts in economic and social aspects in order to formulate an *integrated system for the technology transfer*, let me add one more quality of the technologist:

—To accompany to the highest level of experience and use of the most sophisticated techniques a genuine "modesty," so as to individuate — among a large range of choices — the appropriate technology, even if at a lower step when compared with much more prestigious possibilities.

From LES Italy International Conference

With respect to developing countries the following classes of technologies are available (this terminology is generally adopted and references in brackets are only made as an example):

1. Free technologies (utilization of local resources and elements: water filtering using local means such as coir, exploitation of the force of the wind).

2. Low-cost technologies (supply with manual tools for agricultural and handicraft works).

3. Soft technologies (tools, small machines and looms for handicraft works or transports).

4. Alternative technologies (evolution from techniques used by family groups to activities in cooperation, suggestions in order to innovate production systems in existence).

5. Intermediate technologies (first level of mechanization in the agricultural field, use of fertilizers in cultivations, reforestation, marsh reclamation, storage of agricultural products by means of expediencies inserted on local activities).

6. Appropriate technologies (prevalance of adaptation factors to the social reality and local traditions and technological contents acquired through continuous evolutions).

7. Progressive technologies (gradual mechanization in agriculture, introduction of methods for the foodstuffs storage, irrigation, evolution from handicraft to small-sized industries).

8. Modern technologies (for the metallurgical and electrical industry, road and port constructions, mining works).

9. Advanced technologies (for the electronic, chemical and mining industry, informatics, robots and means replacing human activity).

10. Aggressive technologies (nuclear, chemcial and oil energy, aeronautics, armaments and very advanced or sophisticated researches).

And with reference to their social and legal aspects:

—Private technology;

—Community technology;

—Public technology;

*Director of the Institute of Technologia Meccanica and Pro-Rector of the Politecnico of Turin, Italy.

(the legal and economic implications arising out of these three classes of technologies are beyond the specific competence of the technologist).

Of course not always and anywhere the bounds dividing a hierarchy class from the following one are clean-cut and not always these bounds are identical for the same class when compared with various areas.

On the contrary, the separation between the classes definable as "labor-intensive"' and the ones characterized by a low contents of labor (i.e. the two classes: "advanced" and "aggressive") is more evident, whereas the concept of "modern technology" is less definite, as it may imply either a high or a low contents of labor according to the technological field (for instance: electronic industry – chemical industry).

The technologist generally finds himself in the following decisional situations:

—He is "upstream"- consulted in order to know which technologies are available for a given production or for a given field and what he suggests.

—He is "downstream"-consulted, submitting to him basic decisions already taken by sources and various justifications (governmental, of political choice, multinational) in order to suggest the *practical implementation* of a technology already defined.

Substantially his task does not change since, in the second case too, technologists have to stress all the points stated at the beginning; therefore his responsibility is greater in the first case.

Contingent Trends

It is also to be noted that, beyond the specific competence and the typically technical needs technologists too feel the effects of contingent trends and orientation changes arising out of causes not connected with technology (political events, sociological directions, ideological principles, economic shocks). At least in theory they must or can point out the strictly technical aspects. But, where needed, they must or can insert their answers within the operative structure presented to them, suggesting the most suitable technology.

At present the prevailing conditions may be roughly indentified as follows:

—Rigid-planned economies: demand of technologies under 8, 9 and 10 (modern, advanced, aggressive).

—Economies characterized by a rapid growth and/or by a high coefficient of capital: technologies under 5 to 10.

—Slowly developing economies: technologies under 3 to 7.

—Very low economies: technologies under 1 and 2 (free and low-cost technologies).

The whole range of "values" (scientific, technical, economic and human) of the technologies from the simplest one to the most sophisticated one is taken into account.

Historically it is possible to attempt a perspective sequence as follows:

—Phase of the development programs for the Third World founded on basic technologies at a high level of capital, energy resources, automation.

—Phase of the necessary integration of infrastructures characterized by technologies at an intermediate level.

—Phase of the sudden emergence of oil-producing countries and use of technologies characterized by a high cost and prestige, financed by means of petrodollars.

—Concomitant phase of "tuning up" of low-cost or soft technologies for the "Fourth World".

—Energy and ecological phase: crisis of the energy sources, anti-pollution and safety standards.

—Present phase:

- Research of appropriate technologies taking into particular account that 80 to 90% of the population of the Third World are rural and that subsistence conditions and premises for a primary development are to be previously guaranteed and created for most of them.
- Acknowledgment of the role to be played by the appropriate technologies as a consequence of human, social and economic failures due to the abrupt introduction of modern or advanced technologies.
- Careful evaluation and alternative choices of technologies based on a high or low contents of labor, or on a high or low financial investment.

I think of having outlined the "scenario" within which technologists have to operate and calibrate their suggestions, as a parameter of a system consisting of other binding components of an ideological, political, ecological, financial, legal, social and above all human character.

—Perhaps this is the time when the technologist is asked to resist to the instinctive temptation to always suggest the most advanced technology: not as a complete or permanent renunciation, since there are exceptions of a high specific weight, but as a well-reasoned adhesion to contingent needs and recommandations of international bodies, qualified in research on technologies at the first levels, responding to the expectations of those who most urgently need help.

More Prepared

Nowadays the emerging countries are much more prepared and aware of the technological options, so as to better meet their real need: such an attitude being probably affected by "cultural revolutions" – in a large nonspecific meaning of this term – criticizing the social tensions caused by hyperconsumerism and favorable to the promotion of appropriate technologies.

At present in weighing the various options we have to clearly distinguish between the material contents, the so-called hardware (plants, machinery, equipment, transports, roads, dams and the like) and the immaterial contents, the so-called software (degree of knowledge, experience, training methods, organizations forms) in order to consistently acquire all the necessary factors. It has been proved that the industrial development even at its first stage is inconsistent with a community lacking in craftsmen or only elementarily-qualified labor. It is furthermore proved that any modern technology on a large scale is neither neutral nor equalitarian from the social viewpoint, as it tends to stress the economic gaps existing in the communities, above all in those of small- or medium-size and in the backward areas, between a minority getting profit

and benefit from this technology and the majority which does not take part in it and suffers the consequences.

The most evident and meaningful limit is represented by the advanced military technologies which are at present desired, required and cultivated in more than one emerging country but which are completely "cloistered," without entailing a wider modernization of the industrial structure with ensuing dissemination and fallout.

Therefore the question of whether the developing countries have to aim at advanced technologies or whether it is more convenient to adopt technologies at appropriate levels is still unanswered.

Before examining the crucial point, i.e. to choose between labor-intensive or advanced technology, and as this choice requires the preliminary acquisition of the data according to which it is to be made, it is convenient to consider which are the elements common in every case.

Under the technological viewpoint such elements are listed as follows:

—Machines, equipment, fixtures, devices, instruments characterized by:

- A very simple design.
- A very easy maintenance.
- A highest resistance to dust, temperature changes, humidity.
- Efficient visual or acoustic signaling systems for troubles or necessary replacement of components.

—Supply with infrastructures of immediate use for the operating of technologies.

—Available spare parts arranged on purchase of equipment, machines etc. and gradually supplied according to a program determined as to its schedule and contents.

—Definition of the technical performance, at various levels, of the personnel and recruiting and/or instruction/training modalities.

—Permanent or periodically scheduled service made available by the supplier of technologies.

These technological premises are the indispensable "plafond," the lack of which makes the initiatives unsuccessful, while their observance leads to developments and positive results.

Consequently it results that:

—The technologies for the developing countries are to be prepared or adapted "ad hoc," before being offered, whatever the application field and the degree of simplicity/complexity are.

—Besides technologies it is necessary to offer at the same time all services permitting their effective operating.

—Furthermore the problem concerning labor and therefore qualification must be solved:

- With any great gaps for the manpower to be assigned both to current and automated technologies, for the identification of the human and psychological factors connected with work environment, machine or assembly work, discipline and hierarchy.
- With great gaps, at management level, according to whether modest- and small-scale technologies or innovated technologies on a middle scale or advanced technologies on a large scale are adopted. In this connection we have to take into account once again the role performed by universities and technical schools. With respect to their activity the task of the technologist consists in pointing out the technical knowledge, classified according to contents and level, of the personnel who shall have to deal with the technologies to be applied (with the exception of some very specific and advanced specializations).

It is evident that every point here outlined entails not only specific researches, studies, surveys, tests, pilot experiments but also permanent economic considerations, since the technological aspect may never be dissociated from the economic one.

Therefore, nobody can play the expert in technologies for the developing countries; the non-observance of this consideration and the indiscriminate offer of technologies different in contents and size to the Third World have caused failures and reactions, therefore repentances or refusals.

Nothing may be firmly and profitably achieved at short term; technologists must be aware of and take into consideration this point, even if they exploit their creative faculties in order to reduce the application times by means of adaptation programs and suitable expediencies.

The first choice between labor-intensive and sophisticated technologies is generally made at a level not connected with technology.

It depends first of all:

—On the ideological choice: centralized planning of a rigid type or articulated at a regional/field level, framed into a given basic "philosophy".

—On the policy chosen by governments: highest possible employment (in the primary field, industrialization on a quantitative basis in the secondary field) characterized by a slow but wide improvement of an economic development of a subsistence; or governmental interventions on fields such as energy sources (dam construction, hydro- and thermoelectric or nuclear power plants), row materials (mines), extraction and refineries, iron metallurgy/steelworks, roads, transports, communications, port facilities, besides social services (schools, hospitals, etc).

—On needs of prestige, leadership, defense-offense and therefore purchase of armaments, or advanced technologies on a large scale in order to condition the neighboring countries from the geographic, political and economic viewpoint.

These premises are not anywhere lasting owing to domestic or international political events and governmental and economic changes. However there is no doubt that given a determined philosopy, the technological choice has to be framed within that philosophy, so as to be consistent with the economic and social system (or nonsystem) and with the expectations of the purchaser.

Any forcing aimed at placing a given technology in a context which is neither suitable nor gradually prepared to receive it, is unsuccessful from the technical as well as from the economic viewpoint (and consequently from the social and political one, with a whole range of extratechnological implications so heavy as to jeopardize the final results). The present phase of industrialization-organization is characterized by the definition of a *science of systems* encouraged by the processing of mathematical models and by the availability of exceptional calculation means (computers) and by the possibility of collecting the desired quantity of data

and storing it. "Systematics" and "Informatics" are the two prevailing components in the present evolution and the two basic points of the forecast techniques.

Their very wide potential applications involve all fields of the human activity; therefore in this report only two aspects are considered:

—*Integrated manufacturing systems.*

—*Developing integrated systems for emerging countries.*

The first aspect concerns fields with a high level of industrialization; through the various degrees of automation it aims at the model of a "manpowerless plant;" exclusively governed by a centralized computer within a forecast and operative context based on a mathematical model, in which all parameters in question have been taken into account.

Second Aspect

The second aspect — as far as the subject matter of this Congress is concerned — avails itself of the systematic and informatic techniques in order to process some standard models to which the single situations are to be referred. The models already available encompass a range of different situations from microdevelopment hypothesis to macroprojects: one can find current suggestions apt to be immediately implemented as well as extremely complex equations, appealing for their elegant mathematical and statistical structure, but sometimes hard to be converted into practical implementations.

A realistic attitude is the most effective premise, as well as a clear concept of a developing integrated system for emerging countries, is the most effective guarantee for achieving lasting successes.

The parameters of the "system" within which we have to previously distinguish variables (and their degree of variability) or constants (and their life as such)are:

—Class of technology adopted.

—Necessary energy and output means.

—Indispensable degree of technological knowledge.

—Necessary quantity of labor, quality and qualifications.

—Cost per head for the creation of jobs, according to the funds available.

—Evaluation of the technical and economic infrastructures in existence or to be created for the application of the technology and its operating.

—Times and ways of construction/execution/starting/management.

—Times and ways for the labor training.

—Cost factors.

—Market, transport, distribution factors.

—Coefficient of productivity (from the beginning to the full utilization of the production apparatus).

—Supply with spare parts; technical assistance, consulting services.

—Obsolescence forecast concerning technique and labor.

—Social implications in the community where the technology is applied.

—Possible promotion of activities (supporting or collateral or derived).

—Cooperation with local training bodies (universities, technical schools) and applied research (for the adaptation on site of some elements of the technology and for the acquisition of limited corrective factors).

—Rentability index required.

Only a preliminary study which allows to identify at first the outlines and contents of the most suitable system and subsequently the requirements of every single component of the system (verifying their existence or not, their lack or sufficiency etc.) permits to choose one or more proposable techniques.

Subsequently, for the chosen technology — or for the proposable ones compared in an optimal way — an analysis is carried out under the above mentioned outline, thus coming to the formulation of a proposal well framed into the operative reality to which it is destined.

The cooperation with experts in economics (at general, field, enterprise levels) and sociology — besides, of course, experts in legal and commercial aspects connected with the various forms of technology transfer — is material for the implementation of an *integrated system.*

That proves the validity of the statement that — when a given investment in technology is foreseen — according to complexity, 1 to 5% are to be destined to the *preliminary study* in order to identify the most suitable "system."

At this point of my schematic and intentionally depersonalized "excursus" I can not abstain from inserting a brief reference to the problem of instruction and training, even if this might "personalize" this dramatic point.

I have just come back from a mission in South America on behalf of OEA (Organisacion Estados Americanos) for a survey and the preparation of an immediate program of aid in Venezuela and Bolivia. The comparison between these two countries is not only symptomatic but even typical; they are two emerging countries; the former is characterized by a bursting economy, the latter by an extreme level of poverty (in some regions the yearly income per family is equal to U.S. $50). I have carried out a parallel study stressing differences, gaps, contrasts existing both in the past and in the present, as well as in the forecast for the future.

Position to Verify

Furthermore, I was in a position to verify the possibility of adopting almost all classes of technologies from the simplest one to the most futuristic ones, just taking into consideration the reality and needs of two countries of the Third World, which are nearly neighboring in the same continent but so different from each other.

I have considered which different aid should be given and the distance existing now and much more in the future between their economic and technical development, thus increasing the gap already in existence.

However a few aspects are common: first, the tragic lack of skilled labor at all levels. There is a dramatic need to train labor (Bolivia), there is an absolute need of taking some measures at once (Venezuela). In both cases fragmentary attempts, limited in size and quality, have been made, aiming at two objectives:

—A foreign entrepreneur (or group) inserts, within

an activity he intends to carry out an "item" in order to recruit and train the labor required, examining case by case the modalities chosen among the various forms available and already tested.

—Government tries to create directly or through special bodies an educational basis in order to guarantee the first rudiments (literacy, arithmetics, drawing, elementary technical applications) upon which it is possible to insert a second stage of instruction and more qualified technical preparation.

The program and its purposes are clear: in practice great difficulties arise owing to the lack of didactic means, equipment, teachers, textbooks and handbooks as well as owing to the lack of bent for learning/teaching, of concrete purposes, of rational methods and coordination.

This is the field in which, for the time being, steps have to be immediately taken on a large scale. In this connection the examples available are numerous and all meaningful.

Here I limit the problem to licensing. Once again I draw the attention to this aspect — we have not to confine ourselves to transfer technology but also know-how, i.e. we must know how to implement it, focusing first on local labor problems such as, where, how, how much to be recruited; where, how, how much to be trained; with whom, by which means, how long, at which level.

As a technologist I have been asked these questions all over the world — from Australia to Korea, from South Africa to Ghana, Nigeria, Ivory Coast, from Madagascar to South America and also in the Republic of China.

Whatever the proposals and the mainlines directed to industrialization are, the basic problem persists everywhere identical in its formulation: to instruct, train, qualify and therefore to know how to teach and how to make people learned, so as to not irremediably jeopardize the implementation of any theoretically-perfect project.

As already mentioned, an initial completely free choice between technologies with a high or low contents of labor is hardly made, pre-existing an ideological, political and economic bond: one is in front of choices already made or needs necessarily prescriptive for the real starting conditions.

When an option is possible, people jointly responsible for the preparation of alternative proposals shall have to point out:

—Premises.
—Conditions of feasibility.
—Costs.
—Consequences.

Even if nowadays supporters of a labor-intensive technology seem to prevail, producing human, social and economic considerations as well as considerations of subsistence or development, it is also true that advocates of modern and advanced techniques have still at their disposal sound arguments. Time does not allow me to exemplify or list the pros and the cons, but data and observations are available.

I think of having briefly indicated tasks and roles to be performed by technologists, classes of technology, contents of the demand, phases and kind of interventions, factors conditioning choice, situations for the basic choice, elements for the "tuning up" of developing integrated systems.

I also think of being in a position to state that according to the positive and negative experiences to date acquired, besides the specific technological epistemology (i.e. critical study of the state of knowledge), it is possible to identify case-by-case and in an effective way the appropriate forms of technical intervention, both within the range of technologies at a various level of automation and within the range of intensive techniques.

The technologist must make his own capability available in order to act in both directions, being in a position to avail himself of proven or ascertainable data, rapid and unfailing calculation means and — the last but not the least — of the practical sense which will never have to be left out.

I hope that those who expected from me a clean-cut suggestion of alternatives, have realized the actual impossibility of drawing a sole and final solution, and those who were prepared for collecting methodological elements of evaluation and choice have found in my report at least systematic outlines.